WEST VIRGINIA
DIVISION OF HIGHWAYS

DIVISION 500
RIGID PAVEMENTS

CONSTRUCTION MANUAL

2002

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Section 501

PORTLAND CEMENT CONCRETE PAVEMENT

501.1 GENERAL

The performance of Portland cement concrete (PCC) pavement depends primarily on the adequacy of the pavement's structural and mix design and the quality achieved in producing, placing, consolidating, and finishing the mix. Although adequate designs may be ultimately specified, misunderstood or misapplied specifications and the use of poor construction techniques and improper equipment operations can greatly affect pavement quality. Section 501 of the **Standard Specifications** establishes the respective obligations of the Contractor and WVDOH. The following Sections present specific WVDOH policies, procedures, and additional clarifying information on PCC pavement construction.

501.1.1 Description of Work

The construction of PCC pavements is a highly mechanized operation that requires inspection of a vast quantity of material and a working knowledge of numerous types of equipment. The Project Engineer/Supervisor and the Project Inspectors assigned to the work should be thoroughly familiar with the details of the Contract Plans and Specifications, Special Provisions, Quality Control Plan, Maintenance of Traffic Plan, and specific orders of work. In general, the Project Inspector is responsible for ensuring that component materials and the final PCC mix conform to the quality requirements of the Contract and that production is in conformance with the Contractor's Quality Control Plan. The Project Inspector also is responsible for ensuring that the PCC pavement is constructed on a suitably prepared subgrade or base course. The final PCC pavement should conform to the lines, grades, thickness, typical sections, and surface smoothness requirements of the Contract. As with any construction operation, the work zone should be frequently checked for conformance with the Maintenance of Traffic Plan.

501.1.2 Source Approvals, Laboratory Numbers, and Certifications

Material source approvals, laboratory numbers, and certifications (e.g., certificates of compliance) must be obtained in accordance with appropriate WVDOH policies and procedures before the materials are used in the work. Check that such approvals and certificates have been properly obtained, and document all laboratory numbers on the Inspector's Daily Report. The Contractor is responsible for notifying the Project Engineer/Supervisor of any change in the source of materials, because such changes may require submittal of a revised Mix Design Plan. See Section 501.1.8 for additional information.

501.1.3 PCC Mix Materials

The following Sections discuss the component materials that are typically used to produce Portland cement concrete pavement mixes.

501.1.3.1 Aggregate Materials

Regardless of whether aggregate materials are tested at the source or the job site, a test report and laboratory number will accompany the delivery of the material. Check the documents for acceptability before the material is incorporated in the work. Ensure that laboratory numbers are properly documented on the appropriate attachments of the Inspector's Daily Report. The material specifications for fine and

coarse aggregates are governed by Sections 702.1 and 703.1 through 703.1.4 of the **Standard Specifications**. Consider the following:

1. Pozzolanic Additives. Pozzolanic additives generally include fly ash, granulated blast-furnace slag, and microsilica. It is acceptable for the Contractor to use such additives as long as the material conforms to the requirements of Section 707.4 of the **Standard Specifications**. The Contactor first must obtain source approval from the Division. Where pozzolanic material is stored at the job site, check that the material is enclosed in weatherproof bins and kept free from contamination. Material from different sources or lots should be stored separately.

2. Recycled Materials. On reconstruction projects, the Contract Plans may specify PCC pavement recycling. The pavement generally will be broken in place, crushed, and screened. The resulting aggregate material then will be reused in the new PCC mix. Existing reinforcing steel and HMA overlay material, if present, will be removed and disposed of properly to minimize contamination of the recycled material. Observe the breaking operation for extensive disturbance of the underlying subgrade or base material. Such disturbance may require unnecessary reworking of the subgrade.

501.1.3.2 Cement Material

The materials specifications for cement are defined in Sections 701.1 and 701.3 of the **Standard Specifications**. The Division generally requires pretesting and source approval. Verify that the Contractor is using an approved source. During the operation, the Contractor may stockpile cement material at the job site. In such instances, check that the material is kept dry and free of contamination and that material from different sources are stored separately. Maintain records on the length of time the Contractor stores cement on the job site. Retesting may be required if the material is stored for a period greater than 90 days. Material failing such tests will be promptly removed from the job site so that it will not be incorporated in the work.

501.1.3.3 Mix Water

Water from public treatment systems is generally acceptable for use in Portland cement concrete mixes. However, water from other sources must be pretested and approved in accordance with MP 715.07.20 and frequently monitored for compliance. Where a pipe or hose is used to draw water from a stream or standing water, check that the intake end is covered with wire mesh and is maintained free of foreign matter. Water from temporary settlement containers should be drawn above the layer of sediment. Where water is hauled to the job site, check that the haul containers are clean and properly covered. The Project Inspector at the plant is responsible for quality assurance of water where central mixing or ready-mix facilities are used. If on-the-job or site mixing operations are used, the quality assurance of water is the responsibility of the Project Inspector at the paving site.

501.1.3.4 Admixture Materials

The use of admixtures in Portland cement concrete is generally governed by the following:

1. Air-Entraining Admixtures. Air-entraining admixtures are governed by the requirements of Section 707.1 of the **Standard Specifications** for tests, source approval, and certification. Check that the Contractor uses approved sources and that proper certification is supplied.

2. Water-Reducing and Retarding Admixtures. As required, the Contractor may use either water-reducing or water-retarding admix-

tures in a batch of PCC mix, but not both. Sections 701.2 and 707.3 of the **Standard Specifications** define the test, source approval, and certification requirements. Check that the Contractor uses approved sources and that proper certification is supplied.

501.1.4 PCC Pavement Construction Materials

The following Sections discuss ancillary materials typically used during the construction of Portland cement concrete pavements.

501.1.4.1 Types of Reinforcing Steel

Verify that reinforcing steel is stored on blocks, dunnage, etc. above ground to prevent rusting from standing water. Depending on the requirements of the Contract Plans, the following types of reinforcing steel may be used in the PCC pavement:

1. Deformed and Epoxy-Coated Rebars. The testing and acceptance criteria for reinforcing bars are governed by Section 709.1 of the **Standard Specifications**. In general, this material will be shipped from a source that has been approved by the Division in accordance with the provisions of MP 709.01.50; otherwise, material sampling and testing will be conducted in conformance with MP 700.00.01. Special storage and handling are required to maintain the integrity of epoxy-coated rebars. Check that the Contractor adequately covers epoxy-coated rebars that are stored at the job site. Prolonged exposure to sunlight can degrade the epoxy coating. In addition, periodically spot check the material as it is unloaded and incorporated in the work. If mishandled, the epoxy coating can be damaged, which exposes the underlying steel. If the damage is repairable within the provisions of the Contract, request that the Contractor repair the material before it is incorporated in the work. If the damage exceeds specified limits, the material should be rejected and promptly removed from the job site.

2. Welded-Wire Fabric. The testing and acceptance criteria for welded-wire fabric is governed by Section 709.4 of the **Standard Specifications**. Where welded-wire fabric is used for PCC pavement construction, the Division requires the use of sheet stock, not rolls. If the Contract Plans call for epoxy-coated fabric, check the material for damage and needed repairs.

3. Expanded Metal. Unless otherwise specified in the Contract, the use of expanded metal reinforcement for PCC pavement construction will be governed by Section 709.5 of the **Standard Specifications**.

501.1.4.2 Chairs and Ties

Chairs and ties are typically used to seat and secure the steel reinforcement within PCC pavements. Check that the use of such materials meet the requirements of the Contract Plans and Specifications. Plastic or coated chairs and ties are typically required to minimize rusting and damage to epoxy-coated reinforcing steel.

501.1.4.3 Coated Dowel Bars

Section 709.15 of the **Standard Specifications** governs the material specifications for coated dowel bars. MP 709.01.51 and MP 709.15.50, respectively, govern certification requirements for the coating applicator and the manufacturer. Check the bars upon delivery for any damage to the coating. Reject and have removed from the job site any material that does not meet specified requirements.

501.1.4.4 Joint Tie-Bolt Assemblies

The materials specifications for joint tie-bolt assemblies are governed by Section 709.7 of the **Standard Specifications**. Periodically check that tie-bold assemblies are properly fastened to forms. Typical construction details are illustrated in the **Standard Detail Book – Volume I** and will be included in the Contract Plans.

501.1.4.5 Curing Materials

Materials that are typically used for curing PCC pavements (e.g., polyethylene coated burlap, burlap cloth, waterproof paper, liquid membrane, white polyethylene sheeting) are defined in Sections 707.6 through 707.10 of the **Standard Specifications**. Upon delivery, check the material for any damage. Acceptance is based on visual inspection. Document laboratory numbers on the Inspector's Daily Report.

501.1.4.6 Joint Sealant Materials

Three types of joint sealant materials are typically used in PCC pavement construction: preformed expansion joint filler, preformed elastomeric joint seals and lubricant-adhesive, and Type I low modulus silicone joint sealant and back-up material. Sampling and testing requirements and acceptance criteria for these materials are defined in Sections 708.1, 708.2, and 708.4 of the **Standard Specifications**.

501.1.5 Governing Materials Procedures

The Contractor is responsible for quality control of PCC materials and pavement construction, and the Division is responsible for acceptance sampling and testing. See Sections 701 and 702 for information on material control policies and procedures. Section 703 defines the samples and tests typically required by the Division. As needed, see the following **Materials Procedures** for additional clarification:

1. MP 601.03.51 – Standard Method for Determining Totals Solids in Portland Cement Concrete.
2. MP 601.04.20 – Curing Concrete Test Specimens in the Field.
3. MP 700.00.01 – Sampling and Testing of Materials at the Source.
4. MP 702.00.20 – Determining Free Moisture in Fine Aggregate Using a Speedy Moisture Tester.
5. MP 709.01.50 – Certification of Producers of Steel Bars for Concrete Reinforcement.
6. MP 709.01.51 – Acceptance Criteria for Epoxy Coated Reinforcing Steel.
7. MP 711.03.20 – Air Content of Freshly Mixed Concrete by the Volumetric Method.
8. MP 711.03.23 – Mix Design for Portland Cement Concrete.
9. MP 711.03.25 – Air Content of Freshly Mixed Concrete by the Chace Indicator.
10. MP 711.03.26 – Maintaining Specified Level of Strength in PCC
11. MP 715.07.20 – Standard Method of Test for Determining the Quality of Water Used with Hydraulic Cement.

501.1.6 Quality Control Considerations

The following Sections discuss topics that should be considered with respect to the Contractor's responsibilities for quality control.

501.1.6.1 Quality Control Plan

The Contractor is responsible for developing a Quality Control Plan in conformance with the requirements of MP 601.03.50 and the contract

specifications. The Contractor will generally submit the Quality Control Plan at the Pre-Construction Conference. Do not permit the Contractor to begin work until the Quality Control Plan has been thoroughly reviewed for compliance with the Contract. During construction, check that the Contractor is conducting sampling and testing in accordance with the Quality Control Plan. See Section 702.4.3 for additional information on Quality Control Plans.

501.1.6.2 Technician and Inspector Certification

Check to ensure that the Contractor has at least one certified Portland Cement Concrete Technician on site to direct quality control operations and an adequate number of certified Portland Cement Concrete Inspectors to perform the field sampling and testing required by the Contract. See Section 705 for additional information.

501.1.7 Quality Acceptance Considerations

The following Sections discuss topics that should be considered with respect to the Division's responsibilities for quality assurance.

501.1.7.1 Compressive Strength Evaluation for Opening to Traffic

For each day's paving operation, a minimum of three sets of three concrete test cylinders will be made from the PCC mix. Sampling and testing will be conducted in accordance with Section 501.4.4 of the **Standard Specifications**. The results of compressive strength tests on the specimens will be used to monitor acceptability for opening the paved section to traffic. In general, the paved section will not be opened prior to 28 days, or longer as conditions warrant, after it has been placed and finished. The Project Engineer/Supervisor may, however, permit an earlier opening if test results indicate the paved section has attained its design strength. Prior to opening, check that the paved section has been properly cleaned, signed, marked, and cleared of all obstructions.

501.1.7.2 Compressive Strength Evaluation for Acceptance

Within 28 to 90 days after project completion and prior to final acceptance, the Project Engineer/Supervisor will use the procedures in Section 501.1.7.4 to evaluate compressive strength for project acceptance. Compressive strength acceptance is governed by Section 501.7.5 of the **Standard Specifications** and requires a statistical analysis of test results on pavement cores sampled in accordance with Section 501.19 of the **Standard Specifications**. If a pavement section fails to meet acceptance criteria, enforce the provisions of the Contract with respect to removal of unacceptable work. Although compressive strength is a primary evaluation factor, the Project Engineer/ Supervisor may use other criteria such as freeze-thaw durability, scaling characteristics, abrasion resistance, and density to assess the acceptability of the pavement.

501.1.7.3 Pavement Thickness Evaluation for Acceptance

Within 28 to 90 days after project completion and prior to final acceptance, the Project Engineer/Supervisor will use the procedures in Section 501.1.7.4 to evaluate pavement thickness for project acceptance. The Division will apportion the highway proper and auxiliary features (e.g., intersections, entrances, exists, crossovers, ramps) into sampling units and take a minimum of one core from each (see Section 501.19 of the **Standard Specifications**). The core samples will be measured and the results analyzed for acceptance. Based on the results of the analysis, additional samples and price adjustments may be warranted. If a paved section fails to meet acceptance criteria, enforce the provisions of the Contract with respect to

removal of unacceptable work. If a dispute or claim is anticipated, preserve the core samples so that measurements can be verified by others.

501.1.7.4 Procedures for Pavement Strength and Thickness Evaluation

Use the following procedures to evaluate compressive strength and thickness for acceptance of PCC pavements:

1. Immediately following completion of the paving operation, the District Construction Engineer, or designee, will prepare a straight-line diagram of the pavement identifying key locations by station number. Locations will include beginning and end stations of paving, beginning and end stations of all interchanges, beginning and end stations of each approach slab and structure, stations representing the location and length of entrance and exit areas in urban projects, and station equalities on the project, if applicable.

2. The District Construction Engineer will submit the diagram to the Director of the Contract Administration Division with a letter of transmittal requesting that the project be cored.

3. The Director of the Contract Administration Division will forward the diagram and letter to the Regional Engineer assigned to District for immediate action.

4. The Regional Engineer will coordinate scheduling with the Director of the Materials Control, Soil and Testing Division to ensure that the pavement is cored at the earliest practical date.

5. Within 28 to 90 days after the pavement is placed, the Materials Control, Soil and Testing Division will core the pavement and perform compressive strength and pavement thickness analyses in accordance with the requirements of the contract specifications. The results will be documented in a Core Report

6. The Director of the Materials Control, Soil and Testing Division will forward the Core Report to the District Construction Engineer, one copy to the Director of the Contract Administration Division, and one copy to the Federal Highway Administration, as applicable.

7. As part of the tentative final for the project, the District Construction Engineer, or designee, will analyze the Core Report and make recommendations to the Project Engineer/Supervisor. Price adjustments may be warranted based on the provisions of the Contract. Such adjustments are typically entered on the estimate once the Core Report becomes available. Early resolution of deficiencies will minimize paperwork and will expedite the project's final estimate and final audit.

501.1.7.5 Refilling Holes After Pavement Coring

After the pavement is cored for acceptance evaluation, the Contractor is responsible for refilling core holes at no additional cost to the Division. Failure to do so will promote water infiltration and cause subgrade/subbase failures. It is preferable to fill the holes with the PCC mix used on the project; however, if unavailable, the Contractor may use a non-shrink grout meeting the requirements of Section 715.5 of the **Standard Specifications**. Contact the Materials Control, Soil and Testing Division for a list of acceptable grout materials.

501.1.7.6 Surface Smoothness Evaluation for Acceptance

Within 30 days after project completion, the Project Engineer/Supervisor will make arrangements to evaluate the smoothness of the final riding surface using an inertial profilometer or a

calibrated Mays Ride Meter. The pavement will be divided into sampling units (i.e. lengths of paved sections) and tested in accordance with Section 501.13 of the **Standard Specifications**. A paved section will be considered acceptable if it exhibits a smoothness value that meets or exceeds the contract specifications. Price adjustments may be warranted based on the provisions of the Contract. Paved sections failing to meet specified requirements by 50% or greater will not be considered acceptable and will be corrected in accordance with the provisions of the Contract (e.g., grinding, sandblasting, leveling with epoxy bonded mortar, reestablishing surface texture). Where a smoothness profile is run across a joint that demarks different project termini (e.g., existing pavement adjoining new, bridge approach adjoining mainline under separate contract), pay particular attention to how smoothness is evaluated across the joint and how the cost of any corrective measure is apportioned. The Division's ultimate objective is to provide the public with a smooth riding surface, regardless of the number of contractors involved.

501.1.8 PCC Mix Design Plan

The Contractor is responsible for developing a Mix Design Plan in accordance with the criteria presented in MP 711.03.23. The Mix Design Plan will become a permanent project record. The Mix Design Plan will include:

1. mix proportions;

2. gallons (liters) of water per sack assumed in arriving at mix quantities;

3. specific gravity, dry rodded weight per cubic foot (cubic meter) and percent absorption of fine aggregate, coarse aggregate (fine fraction), and coarse aggregate (coarse fraction);

4. target percent of air assumed in arriving at mix quantities;

5. batch weights for a cubic yard (cubic meter) of air-entrained concrete;

6. source of materials; and

7. certified test data from a Division-approved laboratory ensuring the adequacy of the mix (e.g., compressive strength, consistency).

Generally, the Contractor will submit the Mix Design Plan to the Project Engineer/Supervisor at the Pre-Construction Conference. The paving operation will not begin until the Mix Design Plan has been checked for conformance with MP 711.03.23 and the contract specifications. The certified PCC Technician will use the Mix Design Plan to control mixing and batching operations. During the project, the Contractor will immediately notify the Project Engineer/Supervisor of any need to change materials (e.g., source, proportions, admixtures). Such requests are generally for the purpose of adjusting yield, strength, or consistency, and the Contract provisions may require the Contractor to submit a revised Mix Design Plan.

501.1.9 Paving Limitations and Pavement Protection

The following Sections discuss topics that should be considered with respect to paving limitations and protection of the newly constructed pavement.

501.1.9.1 Cold-Weather Paving

Normally, the mixing and placement of concrete should be discontinued when the ambient temperature reaches 40°F (4°C) and is descending. Operations should not be resumed until the ambient temperature reaches 35°F (2°C) and is ascending. If paving is anticipated during the colder months of the year, the Contractor's PCC Paving Plan should adequately address cold-weather paving. Consider the following guidelines:

1. Temperatures Below 55°F (13°C). Enforce the Contract provisions for cold-weather paving when the temperature of the plastic concrete drops below 55°F (13°C). Under such cases, the Contractor must provide adequate means to heat and maintain the temperature of the plastic concrete between 50°F (10°C) and 85°F (30°C) during placement. When it is necessary to heat component materials (e.g., mixing water, aggregates), check that the Contractor uniformly heats the material to the required temperature and that the temperature of the material does not exceed 150°F (65°C). Overheating must be avoided through close monitoring. Acceptable methods of heating will be defined in the provisions of the Contract. Note that methods of heating which alter or prevent air entrainment and the use of live steam on or through binned aggregate material will not be permitted.

2. Temperatures Below 35°F (2°C). When the ambient temperature is expected to fall below 35°F (2°C), check that the Contractor adequately covers the pavement with a suitable blanketing material of sufficient thickness to prevent freezing of the concrete during curing. Do not allow the Contractor to use frozen material or pave over frozen subgrade or base material.

501.1.9.2 Hot-Weather Paving

When paving is to be performed during the hotter months of the year, the Contractor's PCC Paving Plan should adequately address hot-weather paving. During hot, dry, and windy conditions, precautionary measures are required to prevent rapid surface drying and unacceptable temperature increases in the concrete during curing. Such conditions may remove moisture from the paved surface faster than it can be replaced by normal bleeding. This will cause shrinkage cracks to form. Consider the following guidelines:

1. Temperatures Above 85°F (30°C). Enforce the Contract provisions for hot-weather paving when the ambient temperature approaches 85°F (30°C). Under this condition, monitor the temperature of the plastic concrete frequently. When the plastic concrete itself reaches 85°F (30°C), ensure that mixing time does not exceed 45 minutes and that the Contractor is sprinkling or wetting the subgrade and forms, maintaining the aggregate in a saturated surface-dry condition, and promptly beginning the curing operation. The application of curing material immediately after finishing is extremely important and, under some conditions, it may be necessary to place wet burlap or cotton mats on the surface for the first 24 hours. If the wet burlap or mat is removed, ensure that Contractor replaces it with an approved curing material during the remaining curing period.

2. Temperatures Above 90°F (32°C). When the temperature of the plastic concrete reaches 90°F (32°C), take immediate action to ensure cooling of component materials (e.g., water, aggregate). The introduction of crushed or flaked ice in the mixing water or mixer is acceptable as long as the water proportion is properly adjusted. Under no circumstance allow the Contractor to pave with a mix that exceeds 90°F (32°C) after mixing.

501.1.9.3 Inclement Weather

Prior to starting the paving operation, check that the Contractor has sufficient material on hand (e.g., forms, burlap, cotton mats, curing paper, polyethylene sheeting) to properly protect the exposed surfaces of any unhardened concrete. The washing effect of sudden showers and downpours will remove the cement component from these surfaces. If rain is imminent, inform the Contractor to cease mixing, paving, and finishing operations and immediately cover the exposed unhardened surfaces. Under such cases, the Contractor still must finish the surface of the

freshly poured concrete. This may be accomplished in one or two ways as follows:

1. Brief Showers. If the shower is brief, the Contractor may completely remove the protective covering after it rains and then finish the surface of the freshly poured concrete.

2. Continuous Showers. For continuous showers, the Contractor must repeatedly roll back the protective covering approximately 3 ft. (1 m) at a time, finish the surface, and replace the covering without marring the finished surface.

As soon as practical, inspect the surface for defects, and immediately inform the Contractor of any needed repairs. Note your findings and directives to the Contractor on the appropriate attachment on the Inspector's Daily Report.

501.1.9.4 Protection of Pavement

The edges and the surface of the finished PCC pavement must be protected against damage from vehicular traffic and construction equipment. The edges of slabs in areas where traffic is permitted to cross the new pavement prior to shoulder construction is especially susceptible to damage. Wood blocking, for example, may be used along and against the edge of the slab to minimize potential damage from cross traffic. Visually inspect the edges and surface before acceptance, and ensure that the Contractor repairs any damage.

501.1.10 Maintenance of Traffic (MOT) Plan

All DOH construction projects will provide for the safe and efficient maintenance of traffic through the work zone. Large and complex paving jobs typically require a Maintenance of Traffic (MOT) Plan; however, smaller and less complex jobs will require the use of sound engineering judgment. In either case, the type and location of warning signs, barricades, pavement markings, flagmen, pilot trucks, and flashers for either daylight or nighttime operations must be in conformance with the DOH publication **Traffic Control for Street and Highway Construction and Maintenance Operations**. During the project, check to ensure that the Contractor is operating in conformance with the requirements of the Contract and document your findings on the appropriate attachment of the Inspector's Daily Report. Require immediate correction of non-conforming items. See Section 636 for additional information on maintaining traffic.

501.1.11 Safety Considerations

Job safety at both the plant and the paving site cannot be overemphasized. Both Division and Contractor personnel must continually practice safe working habits. Occupational Safety and Health Administration (OSHA) regulations must be understood and followed by all personnel. Each person should clearly understand what is expected them and how to perform their assigned tasks. Dust, noise, haul trucks, pavers, and traffic moving through the work area all pose potential hazards. New personnel should be properly instructed, and seasoned personnel should not become lackadaisical or careless. Constant care and vigilance are needed to prevent accidents and injury. It is wise to periodically remind personnel that they are operating in a potentially dangerous environment. If an unsafe work practice is observed, corrective action should be taken immediately, even if the operation has to be temporarily shut down. See Section 107.2.3 of this **Manual** for additional guidance on construction project safety.

501.1.12 Pre-Construction Conference

Section 103.3 of this **Manual** discusses activities that should be considered before construction. Section 103.3.2 specifically addresses the requirements of the Pre-Construction Conference (e.g., purpose and

need, arrangement and scheduling, attendees, facilitation). The Pre-Construction Conference will establish an overall cooperative tone and ensure that all parties involved understand the project and are ready for production work. Prior to starting production and paving operations, the Project Engineer/Supervisor will arrange a meeting with the Project Inspectors and the Contractor's Supervisory Personnel to discuss source and handling of materials, plant site and operations, equipment, methods of operations, and any special requirements of the Contract. The minutes of the meeting will be documented and distributed to the appropriate personnel.

501.1.13 Communication During Project

During the project, quality and safety depend on continued positive and meaningful communication with the Contractor. Frequent informal meetings provide a forum for meaningful dialog to mitigate potential cost and scheduling problems. In addition, frequent communication between plant and paving personnel during production provides critical feedback to ensure a quality pavement. Key points of discussions should be noted in the Inspector's Daily Report.

501.2 PCC PRODUCTION AND HAULING

Based on the provisions of the Contract, concrete may be mixed at the paving site, hauled to the site from a plant, or mixed en route to the site using truck mixers. Inspection of these production methods and hauling equipment cannot be overemphasized. They are key to producing a quality PCC pavement. Project Inspectors in charge of production and acceptance must fully appreciate the linear nature of the paving project – from raw component materials to final slab. Quality greatly depends on the attention given during each step. No amount of extra effort at the paving site can compensate for errors and omissions at the site of production. Regardless of the methods employed, Project Inspectors must ensure that the mix conforms to the contract specifications before it is incorporated in the work.

501.2.1 Inspection and Certification of Production Facilities

The Division must certify PCC production facilities (e.g., batch plants, central-mix plants) before use. Prior to certification, the Division will inspect the site, operation, and hauling equipment to ascertain adequate supply and control of materials. Scales and weigh hoppers, either manual or automated, will be inspected as discussed in Section 708.1. Meter proportioning equipment will be inspected as discussed in Sections 708.2.2 and 708.2.3. Before production, check that production facilities have been properly inspected and certified. Become familiar with the equipment and operation, and check for obvious signs of unacceptable use or mechanical condition. Verify that systematic and regular checks are conducted in accordance with WVDOH policy. Do not adjust production settings, scales, or meter proportioning equipment, because this is the Contractor's responsibility.

501.2.2 Material Storage and Handling

The following Sections discuss topics that should be considered with respect to material storage and handling.

501.2.2.1 Aggregate Stockpiles

Fine and each size fraction of coarse aggregate material will be separately stored in stockpiles or bins. Check that bins are properly maintained to provide a free flow of material without inadvertent intermingling. See Section 401.4.2.3 for additional information on stockpiling.

501.2.2.2 Moisture Considerations

The mix design assumes latent moisture, so aggregate must be maintained in a saturated surface-dry condition. Excessively dry conditions may warrant wetting at night and sprinkling during the day, but the storage facility must be capable of draining excess water. Verify that moisture tests are conducted as specified, and require additional testing as conditions warrant. Such monitoring is critical to maintaining the water-cement ratio within tolerance.

501.2.2.3 Fly Ash and Cement Storage

Fly ash and cement must be kept dry in weatherproof bins. Dark clumps of material are a sign of previous wetting and may be grounds for rejection.

501.2.2.4 Segregation/Acceptance Considerations

Become familiar with the physical characteristics of acceptable materials, and check for signs of segregation, intermingling, contamination, and breakage. Segregation is common and typically begins with improper handling. Serious segregation is grounds for rejection. Before production, verify source approvals, laboratory numbers and certifications (see Section 501.1.2), and enforce the provisions of the Contract with respect to rejection. Document all findings, including laboratory numbers, on the appropriate attachment of the Inspector's Daily Report.

501.2.3 Mix Proportioning

Aggregate, cement, water, and admixture materials will be proportioned based on the requirements of the PCC Mix Design Plan (see Section 501.1.8). It is good inspection practice to become familiar with the Mix Design Plan including control charts, mix proportions, and methods of determining scale weights and batch quantities. Scales and meter proportioning equipment must be inspected and certified (see Section 501.2.1).

501.2.3.1 Aggregate and Cement Proportions

Aggregate and cement typically are proportioned by weight using certified scales and weigh hoppers. The tolerance for weighing aggregate material is ±2%. Because the cement proportion is tightly controlled to within ±1%, a separate hopper and scale is normally used for cement. During production, check to ensure cement is discharged completely without loss due to excessive dusting or spillage.

501.2.3.2 Water Proportion

Water will be proportioned by either weight or volume. Inspect connections in the supply line for obvious signs of leakage. Control valves must close completely to prevent delivery of an excessive quantity.

501.2.3.3 Proportioning of Admixtures

Admixtures (e.g., air entrainment, water reducers, water retarders) generally are supplied in liquid form. They are introduced by means of a positive, automatic mechanical dispenser at the time water is discharged into the mixer. If more than one type of admixture is used, each will be separately proportioned. Each supply tank will have a gage indicating the quantity remaining. Check gages periodically to verify proportioning and supply. Visually inspect each supply line for positive flow and obvious signs of leakage.

501.2.4 Mixing Equipment and Methods

The following Sections discuss topics that should be considered with respect to the equipment and methods that are typically used to mix Portland cement concrete for pavement construction.

501.2.4.1 Typical Mixing Operation

After the aggregate, cement, water, and admixture materials have been properly proportioned, they are placed in the mixing unit (e.g., truck-mixer, stationary mixer). A small quantity of the liquid component (i.e., water and admixtures) will be introduced first. The remainder of the liquid component will then be introduced uniformly with the aggregate and cement so that the mixer is completely charged within the first 15 seconds of the required mixing period. Mixers generally have a drum configuration with a series of internal blades. The rotating action of the drum-blade combination lifts and kneads the materials into a uniform mass suitable for paving in terms of consistency and workability. Each mixer generally will have a manufacturer's plate that prominently displays volumetric and rotational speed capacities. Minimum mixing time will be either specified or established (see Section 501.2.5).

501.2.4.2 Mixer Performance and Maintenance

The PCC Technician is responsible for assessing mixer performance. Mixer performance is generally assessed based on three concrete samples per test batch taken at intervals during discharge as specified in the Contract. Check to ensure that these tests are performed as required. See Section 501.2.6 for additional information. Both stationary and truck mixers must be maintained in good working order to minimize delays during production. Consider the following guidelines:

1. Blade Wear. The mixer's blades must be carefully inspected and monitored for wear. The majority of wear will occur at the center of the blade with very little wear at the tips. If worn ¾ in. (20 mm) or more, discontinue use of the mixer until the blades can be either repaired or replaced. Several methods may be used to check blades for excessive wear. Consider the following:

   a. Straightedge. A straightedge, or stringline, can be placed along the length of the blade. The amount of wear can be determined by measuring the distance between the edge of the blade and the edge of the straightedge or stringline at the blade's midpoint.

   b. Telltale. Permanent marks (e.g., holes ¼ in. (6 mm) in diameter) can be provided ¾ in. (20 mm) from the edge of new blades near the midpoint of the length of each blade. This will provide a readily visible check for excessive blade wear.

   c. Manufacturer's Brochure. Blade measurements can be taken and compared to the dimensions illustrated in the manufacturer's brochure. The Contractor is responsible for providing this brochure.

2. Leaks and Spills. Causes of obvious mortar leaks and spills should be addressed and corrected immediately.

3. Cleaning. The throat of the drum and the mixing blades can become fouled with hardened or semi-hardened concrete and, if left unchecked, can cause ineffective mixing and fouling of subsequent batches. Check to ensure that mixers are properly cleaned at suitable intervals.

4. Wash Water. Wash water from auxiliary tanks, if not completely drained from the mixer, will invariably be used in a succeeding batch. Check that a suitable means of measuring this water is employed, or require that the mixer be completely drained between batches.

501.2.5 Mixing Time

Mixing time begins when the component materials are placed in the mixer. Concrete that is mixed less than the established minimum is grounds for rejection. Require adjustments, if

needed, and make appropriate entries on the proper attachment to the Inspector's Daily Report. In no case should the volumetric or speed capacity of the mixer exceed the manufacturer's recommendations.

501.2.5.1 Truck-Mixer Operations

In truck-mixer operations, component materials are mixed for either a specified amount of time or a specified number of revolutions at normal mixing speed. Check the speed of the drum-blade rotation to ensure that it is within specified limits. Close coordination between Project Inspectors at the plant and the paving site is required to ensure proper mixing. Check delivery tickets, revolution counters, and timing devices frequently to verify mixing time.

501.2.5.2 Other Mixing Operations

Mixing time generally should not be less than 75 seconds (i.e., 60 seconds plus 15 seconds for each additional cubic yard (cubic meter) of batch). However, a shorter mixing period can be established if the Contractor demonstrates the adequacy of the resultant mix. Mixing time is typically controlled by a timing device and automatic discharge locking system. An audible warning device signals when the discharge lock is released. Using a stopwatch, check the mixing time from charge to discharge at least once a day during production to verify proper adjustment of the control system. In multiple drum-mixer operations, include the transfer time between drums.

501.2.6 Mix Property Checks and Adjustment

The certified PCC Technician is responsible for overseeing testing to make certain mix properties are within tolerance of the contract specifications. Unless otherwise directed, seven production batches will be sampled, and each property tested should not exceed tolerance in more than one test batch. Grounds for rejection will be based on the type and magnitude of the infraction. When conditions change (e.g., materials, batch size, mixing operation, hauling method), additional testing may be required. It is good practice for the Project Inspector to review the PCC Mix Design Plan and become familiar with mix proportions, methods of determining batch quantities, yield, effective water and cement factor, and the procedures for adjusting mix proportions. During production, changing conditions will invariably require mix adjustments. The PCC Technician will immediately notify the Project Engineer/ Supervisor of any needed adjustments (e.g., changes in material source or proportions, introduction of admixtures), because Contract provisions may require the Contractor to submit a revised Mix Design Plan.

501.2.6.1 Field Laboratory Requirements

The Contractor is responsible for furnishing a field laboratory to maintain adequate control over the quality of materials and work on the project. Sampling and testing will be defined in the Contractor's Quality Control Plan. Prior to production, check that the Contractor locates the facility to permit reasonable observation of key operations and furnishes the facility in accordance with contract specifications. During production, check that the facility is maintained in a clean and orderly condition for the most effective work.

501.2.6.2 Aggregate Gradation Checks

Verify that gradation and uniformity are checked at least once each production day and more frequently as conditions warrant (e.g., changes in aggregate source, use of multiple stockpiles). If outside specified limits, halt production until corrected in accordance with the provisions of the Contract.

Note that changes in aggregate source will require a new mix design.

501.2.6.3 Strength Checks and Adjustment

Make periodic checks of the quantity of cement used. Compare the actual quantity (i.e., the difference between total supply and quantity remaining) to the theoretical quantity determined from the PCC Mix Design Plan. Ensure that the compressive strength is monitored and that the cement factor is adjusted as needed in accordance with the provisions of the Contract. If MP 711.03.26 is used to control the cement factor, the minimum specified criteria should be considered the target value.

501.2.6.4 Consistency (Slump) Checks

Consistency, or slump, is an indicator of concrete workability and must be carefully monitored and held within a narrow margin to assure proper placement and consolidation to the prescribed geometry. Check that consistency is tested and monitored within the limits of the contract specifications. The target value will depend on the method of paving. Slip-form paving generally requires a 2-inch (50-mm) consistency. Excessively wet or dry batches is grounds for rejection. For other paving methods, consistency should be within ¾ in. (20 mm) of the target value. If exceeded, require immediate adjustment. Failure to comply is grounds for rejection. It is generally unacceptable for the Contactor to introduce additional water at the paving site for the purpose of adjusting consistency. This adjustment should be made at the production site. However, water may be added to dry batches in truck mixers if the operation can be performed within 45 minutes of initial mixing. Under such cases, do not permit more than 1 gal/yd^3 (5 L/m^3) to be added and ensure that the batch is remixed for at least 20 drum revolutions at normal mixing speed.

501.2.6.5 Air Entrainment Checks

Check that the amount of entrained air is tested and monitored within the limits of the contract specifications. Require adjustments and reject batches based on the provisions of the Contract.

501.2.6.6 Yield Checks and Adjustment

After consistency and air entrainment have been established for production, ensure that actual yield is verified and properly adjusted. The actual yield is determined from the average unit weight of specified samples and is compared to the theoretical yield of the mix design. In general, mix adjustment is required if the difference is greater than ±2%.

501.2.7 <u>Hauling Considerations</u>

Haul trucks should be inspected for conformance with the contract specifications and the PCC Paving Plan with regard to type, capacity, number, and mechanical condition. The following Sections discuss additional hauling considerations.

501.2.7.1 Truck Types and Maintenance

Agitating and non-agitating type trucks are used to haul concrete from plant and central-mix facilities. Agitating type trucks are frequently specified where consistency and workability of the mix are an issue. The haul container must be maintained free of mortar leaks and hardened concrete. The interior walls should be maintained smooth and clean to allow free and complete discharge of the batch. The container should be covered when conditions warrant.

501.2.7.2 Material Segregation Considerations

Periodically verify that concrete is being discharged completely without segregation. Bottom discharging trucks are preferred because the batch can be deposited directly onto the subgrade with little segregation. Where titling-body type trucks are used, suitable baffles must

be in place to retard the rate of discharge and reduce segregation.

501.2.7.3 Haul Time Considerations

Concrete begins to set when water is introduced to the batch. If excessive time elapses before the concrete reaches the site, mix consistency may be compromised making it difficult to place and finish. Consider the following:

1. Non-Agitating Trucks. Concrete that is hauled in non-agitating trucks shall be placed within 30 minutes or less after water is introduced to the batch.

2. Agitating Trucks and Truck Mixers. Where agitating trucks and truck mixers are used, the concrete shall be placed within 60 minutes or less.

501.3 PRE-PAVING OPERATIONS

The following Sections discuss topics that should be considered with respect to pre-paving operations that are typically performed.

501.3.1 Subgrade Preparation

Prior to paving, verify that the subgrade is graded to the approximate cross-section and compacted to the specified density. Grading and compaction should extend across the full width plus an additional 2 ft. (600 mm) beyond each edge of pavement to accommodate either the fixed forms or the slip-form paver tracks, depending on the paving method employed. See Sections 207 and 228 for additional information on earthwork excavation and subgrade preparation.

501.3.1.1 Fixed-Form Paving Considerations

In fixed-form paving operations, the subgrade should be constructed slightly higher than the required final elevation of the subgrade. This will allow fine elevation adjustments to be made through trimming rather than filling. Check that the 2 ft. (600 mm) wide foundation under the forms is compacted hard and true to grade so that the entire length of each form can be set to specified grade in firm contact with the foundation. A reference stringline is sometimes used to perform these checks. Low spots should be brought up to grade in ½-in. (13-mm) compacted lifts of granular material and extend 18 in. (450 mm) on either side of the form. High spots should be trimmed or tamped as needed.

501.3.1.2 Slip-Form Paving Considerations

In slip-form paving operations, the subgrade and the 2 ft. (600 mm) wide track-path foundation should be at the required final elevation of the subgrade. Verify that each track-path foundation is graded, compacted, and maintained in a smooth condition until the paved section is constructed; otherwise, irregularities will be reflected in the finished surface of the pavement. Irregularities can also be caused where a supported guide wire is used. Check that the guide wire is maintained taut without measurable sag. It is good practice to periodically walk just ahead of the slip-form paver to check for these irregularities and any needed adjustments.

501.3.2 Setting Forms

During the paving operation, check that forms are being set and assembled sufficiently in advance of the paving train to minimize delay and to provide for a continuous operation. Consider the guidelines in the Sections that follow.

501.3.2.1 Form Condition and Acceptability

Before forms are set, verify their acceptability with regard to type, number, dimension, and condition. Straight forms will be used on tangent

sections, and flexible or curved forms will be used for curves with radii of 200 ft. (60 m) or less. Check for forms that have bent flanges, bent, twisted or broken forms, and forms with battered top surfaces. If found, require immediate removal and replacement.

501.3.2.2 Form Stability Considerations

Forms must be capable of withstanding the impact and vibration of consolidating and finishing equipment. Excessive settlement or springing will not be tolerated. Check that forms are tightly secured and free from play or movement in any direction. Verify that locking devices of abutting forms are tightly secured and working properly and that pins are sufficiently long and locked in stake holes. If excessive movement is observed, require the forms to be reset.

501.3.2.3 Tamping and Seating Operation

After the forms have been set, check that the Contractor thoroughly seats the base of the form by tamping the subgrade on each side.

501.3.2.4 Width, Alignment, and Grade Checks

After forms are set and properly tamped, take random measurements and sight along the top of the forms to detect irregularities. Verify the width, alignment, and grade of the forms. Consider the following guidelines:

1. Width. Measure and check the width between the inside face of the forms and the distance each face is from the centerline.

2. Alignment. Verify that the inside face is perpendicular to the subgrade and that it is within ¼ in. (6 mm) of the required alignment.

3. Grade. The top face will establish the grade and should not vary more than 1/8 in. in 10 ft (3 mm in 3 m) of the final grade.

4. Adjustment. Require adjustment, where needed, If adjustments are made, the subgrade at the base of the form must be retamped..

501.3.2.5 Cleaning and Oiling Forms

Just before placing the concrete, verify that the forms have been adequately cleaned and oiled.

501.3.3 Final Grade Conditioning

During the paving operation, check that the grade is constructed sufficiently in advance of the paving train to minimize delay and to provide for a continuous operation. Consider the guidelines in the Sections that follow.

501.3.3.1 Final Shaping

The final grade will be cut with an approved subgrade machine and the extra material moved ahead if needed to correct low spots. If moved ahead and payment for base material is based on weight, deduct the reused quantity from the pay quantity for base material. If not reused, low spots will be brought up to final grade with an approved granular base material.

501.3.3.2 Compaction Operation

After final shaping, verify that a steel-wheel roller is used to compact the base to the density required by the contract specifications. Verify that the type and weight of the roller conform to the provisions of the Contract.

501.3.3.3 Grade Checks

Immediately ahead of the paving operation, check the shape of the base for conformance to the Contract Plans with respect to cross slope, pavement thickness, and grade. The final base can be checked from measurements taken between the grade and a taut stringline that is stretched across the forms. If slip-form paving is employed, use the control hubs established along each edge of pavement to check cross slope. Record the location and measurements of grade checks on the appropriate attachment to the Inspector's Daily Report.

501.3.3.4 Maintenance of Grade

Verify that the final grade is maintained in a smooth and compacted condition ahead of the paving train. Require repairs as needed.

501.3.3.5 Moisture Considerations

Unless a waterproof base material is specified, the grade must be kept uniformly moist at the time the concrete is placed. Verify that the base is sprinkled sufficiently ahead of the paving train to keep the material moist without ponding of water.

501.4 PCC PAVING EQUIPMENT

The Contractor will have the option to utilize either fixed-form or slip-form paving equipment. It is recommended that brochures from the manufacturer of the equipment be obtained from the Contractor. The Contractor's PCC Paving Plan will describe the proposed method of paving, equipment and tools for the work. Prior to starting PCC paving operations, check that the Contractor has on hand the necessary equipment to place, finish, cure, and protect the concrete. Pay particular attention to the adequacy of the equipment's design, capacity, and mechanical condition. Notify the Contractor of any significant deviation from the requirements of the proposed operation or the provisions of the Contract.

501.4.1 <u>Slip-Form Paving Equipment</u>

The slip-form paving method is used to place, spread, form, consolidate, screed and finish plastic concrete in a single-pass operation. These operations may be performed by a single self-contained unit or a train that includes a leading mechanical spreader followed by a slip-form paver. The rigid sliding forms on either side of the paver, which are laterally supported to prevent spreading, progressively form the slab for finishing. Mechanical floats eliminate small surface irregularities in the final finished surface, thus minimizing the need for hand finishing. Slip-form pavers contain various components including auger spreader, spud vibrators, oscillating screeds, clary screed, tamping bars, and pan floats. To ensure quality pavement before the operation begins, verify that the equipment has been properly set and calibrated accordance to the manufacturer's recommendations. Consider the following guidelines:

1. <u>Screeds</u>. Check all screeds with a stringline to ensure that a true plane or crown is provided in accordance with the requirements of the Contract Plans.

2. <u>Elevation</u>. Check the height of the finished pavement elevation to ensure that it conforms to the requirements of the Contract Plans.

3. <u>Vibrators</u>. Check that the type and number of vibrators provided are adequate for proper consolidation across the full width and depth of the slab being placed. Check the vibration frequency to verify that it conforms to the Contract and manufacturer requirements.

4. <u>Line and Grade Sensors</u>. Check the sensitivity of the feelers or sensors and the tightness of the stringline guide to ensure

that adequate control of line and grade will be maintained.

501.4.2 Fixed-Form Paving Equipment

The following Sections discuss the various types of equipment that are typically used in fixed-form paving operations.

501.4.2.1 Mechanical Spreader

Mechanical spreaders are usually equipped with either a screw or plow type distributor. The bottom elevation of the distributor and the strike-off assembly is adjustable. When checking the adjustment of the mechanical spreader, the strike-off should be set level with the top of the forms at which time the gages should read zero. The strike-off should then be adjusted for proper thickness. Finally, the distribution device should be adjusted so that a small quantity of concrete is carried in front of the strike-off.

501.4.2.2 Transverse Finishing Machine

The transverse finishing machine is equipped with two transverse screeds. Verify that the top of the forms are kept free of accumulated material and that the screed wearing plates which ride on the forms are not excessively worn. Use the following procedures to check screed adjustment:

1. Center the screed and lift off forms.

2. Stretch fine wires taut between the forms at the front and back of each screed.

3. Place blocks of uniform thickness on top of the wires at each form.

4. Lower the screeds.

The proper crown is placed in the screed by measuring between the taut wire and the face of the screed and adjusting the hanger bolts. The front screed should be tilted with the front edge slightly higher. The rear screed should be set flat or with a tilt not exceeding 1/16 in. (2 mm). Where two finishing machines are used, the screeds on the rear machine should have little or no tilt.

501.4.2.3 Longitudinal Float Finisher

Float finishers, in general, greatly affect the finished surface because they correct irregularities that are left by proceeding operations. Therefore, adjustment of the float finisher is extremely critical. During the following procedures, the longitudinal float finisher should be loaded with approximately the same weight, including the operator, that it will carry during operation. Verify the alignment of the float along its centerline and both edges as follows:

1. Check the height of the transfer tracks which carry the float assembly, at the front and the rear of the machine, to ensure that all four ends are equidistant from the horizontal plane formed by the bottom of the wheels.

2. Place taut wires across the top of the forms and verify that the tracks are adjusted to conform to the desired cross section of the finished surface.

3. Stretch two wires across the top of the forms at a distance apart equal to the length of the float. When the float is lowered, all four corners of the float should be the same distance from the wires at a distance equal to the ordinate of the desired cross-section.

To ensure proper operation after alignment, verify that the scrapers are in good condition and in solid contact with the flanged wheels or forms at all times. It is unacceptable for the operator to adjust the float to compensate for either a surplus or a deficit of concrete.

501.4.2.4 Transverse Float Finisher

The transverse float finisher is an acceptable alternative to the longitudinal float finisher. The transverse float finisher is carried on a long wheel base frame that rides on the forms and finishes the concrete with transverse oscillating screeds and a stationary float. The front screed normally rides on the forms and may be checked in a similar manner to that described for the transverse finishing machine in Section 501.4.2.2. The second screed and the float do not ride on the forms but are suspended from the frame; therefore, their elevation is much less affected by form irregularities. Check that both screeds and the float are adjusted to the proposed cross-section. When in the down position, verify that the ends of the screeds and the float are set about the same elevation as the top of the forms. Once the operation is started, it is acceptable to make small final adjustments to match the desired cross section and proper surface finish.

501.4.3 Vibrators

Vibrators are used to consolidate plastic concrete as it is placed. Depending on the type of paving method and equipment used, either surface pan or immersed tube or multiple spuds will be mounted on the spreader, finishing machine, or separate carriage. Supplemental hand-operated vibrators also are used to consolidate areas inaccessible to machines.

501.4.3.1 Vibrator Frequency

Before the operation begins, check the frequency of vibrators for compliance. A minimum frequency of 3,500 impulses per minute is generally specified for surface pan vibrators and 5,000 for immersed tubes and spuds. The manufacturer's certification may be used for guidance; however, visual observation at the time of placement will be the determining factor.

501.4.3.2 Spud Vibrators

Spud vibrators typically have an effective working radius of between 5 and 10 inches (125 to 250 mm), depending on the diameter of the spud, its amplitude, and its frequency of vibration. For practicality, spud vibrators should achieve an effective consolidation radius of approximately 9 inches (225 mm), with a frequency of between 5,000 and 10,000 impulses per minute. In general, the higher the frequency, the better the consolidation. A good target frequency is approximately 8,000 to 9,000 impulses per minute. The vibrator tip amplitude is another important factor. This usually ranges from 0.03 to 0.06 inches (0.75 to 1.50 mm). Ideally, the amplitude should be approximately 0.05 inches (1.25 mm).

501.4.4 Hand Tools and Auxiliary Equipment

Prior to paving, verify that the Contractor has available all necessary hand tools and auxiliary finishing equipment (e.g., hand floats, edging tools, concrete saws, shovels). Check this equipment to ensure it conforms to the requirements of the Contract and is in satisfactory condition. When joint sawing is required, it is critical to ensure that the Contractor has a sufficient number of concrete saws, replacement blades, and power to saw joints at a rate that prevents uncontrolled cracking. Lighting for night sawing may be necessary.

501.5 PCC PAVEMENT CONSTRUCTION

The following Sections discuss topics that should be considered with respect to the construction operations that are typically performed at the Portland cement concrete paving site.

501.5.1 Placement of Concrete

The Project Inspector at the paving site must consider many factors regarding the placement of concrete, as discussed in the following Sections.

501.5.1.1 Lane-by-Lane Construction

Unless otherwise directed, concrete will be placed to construct two full-width traffic lanes in one operation; however, lane-by-lane construction is generally permitted for variable width sections and other sections as directed or specified. Pay particular attention to equipment operation on the newly constructed adjoining lane. Finishing equipment is generally permitted to operate on the adjoining lane after three days; however, use by other types of equipment will depend on the specified requirements for opening the lane to traffic.

501.5.1.2 Slip-Form Paving Considerations

Slip-form pavers generally are equipped with an initial strike-off blade that is powered fore and aft independent of the forward travel of the paver. A large screed area is provided to roll excess concrete in a forward direction to fill low spots. Because of the relative force of rolling the excess concrete as compared to the static weight of the machine, concrete consistency and distribution uniformity are extremely critical. Non-uniform distribution and piles of "dry" concrete will cause the paver to float or lift above true grade, resulting in high areas or bumps. To ensure pavement smoothness, it is critical that the quantity of excess concrete ahead of the forward screeds be sufficiently small to allow a rolling action rather than a pushing or shoving action of the excess. Check to ensure that the concrete is of the required consistency and that it is being distributed uniformly and properly placed. See Section 501.2.6 for additional guidance on mix adjustment and concrete consistency. Consider the following additional guidelines:

1. Lane Construction. Where slip-form paving is employed, placement of concrete is generally required across the full width of two lanes. However, the Project Engineer/Supervisor may permit fixed-form, lane-by-lane construction on variable width, small, or otherwise restricted sections. See Section 501.5.1.1 for additional information.

2. Paver Speed. As practical, slip-form pavers should be operated in a continuous forward motion at a speed that is coordinated with production, delivery, and spreading operations. If the paver, or train, must be halted, check to ensure that the vibratory and tamping elements are stopped immediately.

3. Haul Trucks. In slip-form paving operations, haul trucks are generally used to place concrete on dowel assemblies immediately ahead of the spreader. Check to ensure that these haul trucks operate on the shoulder and not on the base course and that the operation does not displace the dowel assemblies.

4. Edge Slumping. Appreciable edge slumping of the in-place concrete is unacceptable. Trailing forms should be required if this condition is evident.

5. Hand Redistribution. If the Contractor is properly using the slip-form paver, minimal hand redistribution will be necessary. As practical, limit this type of handwork and require the Contractor to make immediate corrective adjustment to the operation.

501.5.1.3 Fixed-Form Paving Considerations

In fixed-form operations, it is critical that concrete be placed and distributed in a manner to minimize hand redistribution and segregation of component materials. Specially designed equipment generally are used for this purpose (e.g., transit-mix trucks, agitating haul units, paving mixer buckets). Consider the following guidelines:

1. Protection of Underlying Course. Every precaution must be taken to avoid disturbing the underlying course (e.g., subgrade), because depressions and similar variations will be reflected in the finished pavement. Check to ensure that the subgrade is being adequately maintained. Front end loaders and other similar equipment are not permitted on the subgrade.

2. Discharge. Verify that discharge on the subgrade occurs while the container is moving away from the spreader. Concrete that is dumped in piles from a stationary position will promote segregation, cause non-uniformity during consolidation, increase strain on forms and spreader, and require unnecessary hand redistribution.

3. Intermediate Bulkheads. Concrete will be placed continuously between transverse joints without the use of intermediate bulkheads.

4. Hand Redistribution. Where hand redistribution is necessary, check to ensure that it is performed using shovels rather than rakes. Do not permit personnel to walk through fresh concrete with boots or shoes that are coated with earth or foreign substances.

501.5.1.4 Placement Near Joints

Pay particular attention to the placement of concrete near tie-bar/tie-bolt assemblies, dowel assemblies, and expansion joint filler material. Extreme caution must be used in these areas to avoid bumping, moving, and displacing these materials.

501.5.2 Longitudinal Joint Construction

Longitudinal joints run parallel with the centerline of the facility (e.g., between lanes) and across transverse joints. They will be either cut by sawing or formed at the locations and within tolerance of the dimensions specified in the Contract Plans and Specifications. Where longitudinal joints are formed, they will be constructed by suitable mechanical methods while the concrete is in the plastic state. For information on sawing longitudinal joints, see Section 501.5.11.

501.5.2.1 Tie-Bar/Tie-Bolt Assemblies

Deformed steel tie-bars or tie-bolt assemblies, as specified, will be placed parallel to the pavement surface, at right angles to the longitudinal joint, and at the spacing designated in the Contract Plans. Unless placed by mechanical means immediately behind the spreader, or the strike-off in slip-form paving operations, check that they are installed and rigidly secured by approved supports to prevent displacement during spreading. Verify that tie bars are not painted, coated, or enclosed in tubes or sleeves.

501.5.2.2 Keyways

Where forms are used, keyways for multi-lane paving operations must be held in proper position against the face of the forms. In slip-form operations, check the location of keyways during installation. The keyway form must be removed prior to placement of the adjacent lane. Tie-bars or hook dowels must be correctly spaced and securely fastened.

501.5.3 Transverse Joint Construction

Transverse joints run perpendicular to the centerline of the facility (e.g., across lanes and longitudinal joints). They will be either cut by sawing or formed at the locations and within tolerance of the dimensions specified in the Contract Plans and Specifications. The transverse joints should be continuous across adjoining lanes, including any concrete median or shoulders. Where transverse joints are formed, they will be constructed by suitable mechanical methods while the concrete is in the

plastic state. For information on sawing transverse joints, see Section 501.5.12.

501.5.3.1 Dowel Assemblies

Dowel assemblies, which are embedded in the concrete pavement, consist of coated dowel bars, metal supports, and ancillary components. They are provided at transverse joints to transfer the vehicular load between concrete slabs. Consider the following guidelines:

1. Placement. Dowel bars are placed mid-depth within the concrete pavement and are aligned perpendicular to the transverse joint and parallel to the pavement centerline and surface. The location, lateral, and vertical placement criteria will be detailed in the Contract Plans. Check to ensure that placement is within tolerance of the contract specifications. To properly establish the location of the groove for the transverse joint (e.g., saw cut), dowel assemblies must be laid out and marked in such a manner that the exact center of the dowel can be re-established after the concrete is placed and finished.

2. Installation. Dowel assemblies typically must be installed by hand, unless mechanical installation has been approved by the Project Engineer/Supervisor. After the correct location and alignment have been established, dowel bars must be fixed in position (e.g., metal stakes, pins, welds) to prevent displacement during the concrete pour. Details will be provided in the Contract Plans. At transverse contraction and construction joints, do not permit welding within the middle one-third of the dowel length. Check to ensure that the small wires used to bundle dowel assemblies together during shipping are removed during installation.

3. Bond-Breaking Material. A bond-breaking material is applied to dowel bars to promote free movement after the concrete has set. Typically, a bond-breaking lubricant is applied to dowel bars at the shop. However, where a bond-breaking material is specified for application in the field, check that it is of an approved type and carefully applied over the entire length of the bar just before placement of the concrete. Care should be taken not to place excessive lubricant on the dowel so as not to create a void beneath the bar.

4. End Caps/Sleeves. At expansion joints, the free end of dowel bars will be provided with a close fitting metal cap or sleeve equipped with a stop to prevent closing during the concrete pour. Check to ensure that the dowel caps are placed on the lubricated end of the dowel and that the proper clearance is provided between the closed end of the cap and the end of the bar to accommodate future movement of the concrete slab.

5. Acceptance. The Contractor is fully responsible for supplying, placing, and maintaining the assembly in its proper position and alignment during the paving operation. Acceptance does not relieve the Contractor of this responsibility.

501.5.3.2 Transverse Contraction Joints

Transverse grooves are provided across the pavement surface to create planes of weakness for crack control. These grooves will be either sawed or formed normal to the pavement surface across the mid-length of the dowels. The locations and dimensions of the grooves must be within specified tolerance. Typically, contraction joints are constructed in a two-step process. First, the joint will be established by either initial sawing or forming by an approved mechanical method, after which secondary sawing will be performed. For information on sawing transverse joints, see Section 501.5.12.

501.5.3.3 Transverse Construction Joints

A transverse construction joint will be installed where there is an interruption of more than 30 minutes in the paving operation. Construction joints must not be installed within 10 ft. (3 m) of any expansion or contraction joint. If the concrete placed is insufficient to form a slab at least 10 ft. (3 m) long, verify that the Contractor removes the concrete back to the proceeding joint. Construction joints will be constructed in a manner similar to transverse contraction joints (see Section 501.5.3.2).

501.5.3.4 Transverse Expansion Joints

Transverse expansion joints will be constructed to the dimensions and at the locations required by the Contract Plans and specifications. Check the expansion joint filler material for acceptability. It must be an approved type, one continuous piece from form to form, and shaped to the subgrade and cross-section of the pavement. Verify that the expansion joint filler is held in a vertical position within tolerance of the contract specifications. It is unacceptable to allow plugs of concrete to remain within the expansion space.

501.5.3.5 Expansion Joints For Structures

Expansion joints for structures and bridge approaches will be constructed as required by the Contract Plans and Specifications. Pre-molded, expansion-joint filler material typically is placed around all structures and features projecting through, into, or against the pavement. Expansion joints for bridge approaches will be detailed in the Contract Plans. Verify material acceptability and dimensional tolerance as needed to ensure quality construction.

501.5.4 Placement of Reinforcing Steel

The type and arrangement of reinforcing steel will be designated in the Contract Plans (e.g., fabric, bar mat). To achieve an adequate bond with the concrete, the reinforcing steel must be free from dirt, oil, paint, grease, and excessive rust (i.e., reduction in cross-section). The reinforcement should be placed mid-depth within the concrete pavement. Variation is permitted; however, the minimum concrete cover will not be less than one-third of the pavement depth that is designated in the Contract Plans. There are two basic methods of placing reinforcing steel as follows:

1. One-Layer Construction. Where reinforced concrete pavement is placed in one layer, the reinforcing steel is generally either positioned in advance of the paving operation (e.g., chairs) or placed by approved mechanical or vibratory means while the concrete is in the plastic state. If placement equipment is used, carefully observe and check the placement of the reinforcing steel. If the equipment is not properly adjusted or the slump varies significantly, the reinforcing steel will tend to move from the planned position.

2. Two-Layer Construction. Where reinforced concrete pavement is placed in two layers, the first layer of concrete is placed and struck-off at sufficient length, width, and depth to accommodate the reinforcement. The reinforcing steel is then placed on top of this layer. Within 30 minutes of placing the bottom layer of concrete, the second layer of concrete is placed over the reinforcing steel, struck-off, and finished.

See Section 602 for additional information on reinforcing steel.

501.5.5 Strike-Off and Consolidation

After the plastic concrete is spread and distributed, it will immediately be struck-off and

consolidated to a cross-section and elevation such that, when the concrete is properly consolidated and later finished, the surface of the pavement will be at the designated final cross-section and elevation. The final pass of the strike-off and consolidation operation normally will produce a cross section slightly higher than that designated as the final elevation.

501.5.5.1 Machine Methods

Immediately after placement, the plastic concrete will be distributed over the roadbed and struck-off at the proper cross-section and elevation with either a blade-type or screw-type spreader, depending on the type of paving operation employed (e.g., slip-form, fixed-form). In slip-form paving operations, the plastic concrete is spread and struck-off by a blade. The top surface of the pavement is then shaped and a preliminary finish is imparted to the concrete through the action of a primary screed, which is rigidly attached to the main frame of the slip-form paver, or by an oscillating belt. The purpose of this equipment is to assist in consolidating the plastic concrete and to provide a uniform cross-section at an elevation that is slightly higher than that designated in the Contract Plans. Consider the following guidelines:

1. Adjustment. Verify that the equipment is in proper adjustment to strike-off and consolidate the plastic concrete at the proper cross-section and elevation. When properly adjusted, there should be a uniform roll of concrete in front of the screed. The roll should be sufficient to provide a uniform surface, while leaving sufficient material for the finishing operation. If excess is carried, it will tend to lift the screed off the forms. There also will be surging behind the screed, which results in overloading the equipment that follows. To minimize surge and tearing, the tilt and speed of the screed may need to be adjusted to strike-off and consolidate the particular concrete mix being used. A stiff concrete mix will generally require a rapid oscillation cycle with a long stroke and a slow forward speed. A fluid mix will generally require a slower oscillation cycle with a shorter stroke and a faster forward speed.

2. Number of Screedings. The number of screedings will be determined by field conditions. Excessive screeding should be avoided because it tends to result in undesirable quantities of low strength mortar on the pavement surface.

3. Equipment Wheels/Forms. The wheels of the equipment and the top of the forms should be periodically checked and cleaned as necessary. Substantial accumulation of concrete and dirt will cause the equipment to move up and down. This motion will be reflected in the final pavement surface.

501.5.5.2 Hand Methods

The use of hand methods for the strike-off and consolidation operation is undesirable and generally requires prior approval by the Project Engineer/Supervisor. However, equipment malfunctions do occur. In addition, there will invariably be areas of narrow widths or irregular dimensions inaccessible to machinery. Under these conditions, the use of hand methods is necessary. Consider the following where hand methods are employed:

1. Equipment. Portable hand-operated screeds and spud-type vibrators are typically used where hand methods are employed. This equipment should be checked for acceptability prior to use. Where reinforcement is required, it will be necessary for the Contractor to employ a two-layer construction approach. As such, a second screed will be provided to strike-off the bottom layer of concrete. The surface screed will be at least 2 ft. longer than the maximum width of slab to be struck-off and will be sufficiently rigid to retain its shape under the working conditions.

2. Timing. Strike-off and consolidation using hand methods should begin immediately after the concrete has been placed.

3. Hand Operation. The screed will be moved forward on the forms in the direction the work is progressing, using a combined longitudinal and transverse shearing motion. It is undesirable to lift either end off the forms during the striking operation. The operation will continue until the surface is a uniform texture, true to grade and cross-section, and free from porous areas.

4. Checks. Surface checks with a template or other similar method should be considered to assure that the surface has been struck-off to the desired elevation.

501.5.5.3 Consolidation of Concrete

Consolidation subsides or slumps the plastic concrete while filling internal voids and removing entrapped air. If the concrete is not adequately vibrated, an excessive quantity of entrapped air will remain and optimum consolidation will not be achieved. Over consolidating, however, is highly undesirable, because it segregates component materials and leaves a layer of low-strength mortar on the pavement surface. Vibrators are typically attached to the back of the spreader, the front of the finishing machine, or on a separate piece of equipment. The vibrators will be either the surface type (e.g., screed, pan) or the internal type (e.g., immersed tube, multiple spuds) and will be mounted in such a manner that they will not come into contact with reinforcing steel, joint assemblies, forms, subgrade, or base course. However, the entire width of the pavement must be vibrated to affect adequate consolidation throughout the full depth of the plastic concrete. Hand-operated vibrators are also employed. Consider the following guidelines:

1. Reinforcement and Joints. The concrete adjacent to joints will be firmly placed and consolidated using hand-operated vibrators near joint materials, under and around all transfer devices, joint assemblies, and other features designed to extend into the pavement. Check to ensure that these vibrators do not contact and displace or misalign these items. Caution should be used not to over consolidate these areas.

2. Abutting Slabs/Forms. Special attention must be given to properly consolidate the plastic concrete along the face of abutting slabs and side forms. Visually check that these areas are being properly consolidated with hand-operated vibrators.

3. Stopping Equipment. Do not permit equipment-mounted vibrators to be operated when the paving equipment is not moving in the forward direction. All equipment mounted vibrators must be stopped, either manually or automatically, when the paving machinery stops.

4. Surface Maintenance. Should any concrete fall on or be worked into the surface of a completed slab, check to ensure that it is immediately removed.

5. Spud Vibrators. Consider the following guidelines where spud vibrators are used:

    a. Frequency/Amplitude/Working Radius. Check the frequency of vibrators for compliance at least daily during the paving operation. See Section 501.4.3. for additional information on frequency, amplitude, and working radius.

    b. Surcharge. Spud vibrators must not be drowned in an excessive surcharge of concrete. The surcharge should generally not exceed 6 in. (150 mm) to 8 in. (200 mm).

    c. Spacing of Gang-Mounted Spuds. Based on the diameter of the spud and its amplitude and frequency settings, the actual working radius of a spud vibrator

can be determined from field tests or manufacturer's certified data. This data can be used to determine the optimal spacing of gang-mounted spuds across the width of the pavement. The number of spud vibrators across a 24 ft.(7.2 m) wide slab generally should be between 14 in. and 16 in. to provide adequate consolidation.

d. Equipment Speed/Vibratory Influence. The equipment speed greatly affects the length of time that the gang-mounted vibrators influence the plastic concrete. In general, the speed of travel should be 12 feet per minute or less. A maximum vibrator spacing of 24 in. will generally require less than 10 feet per minute of forward travel, and a maximum spacing of 18 in. will require a speed of 10 to 20 feet per minute. See the American Concrete Institute publication **Recommended Practice for Consolidation of Concrete (AC1309-72)** for additional information.

501.5.6 Floating Operation

After the concrete has been struck-off and consolidated, it will be further smoothed, trued, and consolidated by mechanical or hand methods, as approved by the Project Engineer/ Supervisor, to remove irregularities left by the proceeding operation and shrinkage of the concrete. Excessive floating should be avoided and care must be taken not to work the crown out of the pavement.

501.5.6.1 Machine Methods

Machine methods typically include the use of either longitudinal or transverse floats. Consider the following guidelines:

1. Equipment Adjustment/Maintenance. At the beginning of each day's operation, the float will be checked and adjusted to the design crown of the pavement. If excessive cutting or filling is required, all paving equipment should be checked and adjusted to eliminate the condition. Equipment must be maintained in proper working order.

2. Timing. Floating should not begin until initial settlement of the concrete is complete and will depend on field conditions. If the concrete has not been thoroughly compacted and is in the early stages of shrinkage when the float passes, the final surface will become rough. Floating should be held to a minimum during periods of greater bleeding, because working the surface in the presence of bleed water will dilute the cement paste on the surface of the slab and reduce surface wear resistance and durability.

3. Speed. A continuous operation at a uniform rate of speed is necessary to obtain the most desirable finished surface.

4. Longitudinal Float Considerations. Consider the following where the longitudinal float is employed:

   a. Overlapping Passes. The longitudinal float should be operated so that the entire surface area is covered at least twice. Check that this is accomplished by overlapping the previous transverse pass by one-half the length of the float.

   b. Excess Roll. When operated properly, the longitudinal float will carry a small roll of concrete along all but approximately the rear two feet of its length. Verify that a small amount of mortar is carried ahead of the float at all times.

   c. Speed Adjustment. Require speed adjustment to ensure that succeeding strokes of the float overlap on each transverse trip.

   d. Number of Passes. The float will pass over each area of pavement a sufficient

number of times until the surface shows no variation from straightedge requirements, but excessive operation over a given area will not be permitted.

e. Removal of Water/Laitance. All excess water, laitance, or other foreign material will be wasted over the side forms on each pass.

f. Pipe Floats. Pipe float devices may be used for longitudinal floating where slip-form equipment is used.

5. Transverse Float. When the transverse float is used, the time of operation must be adjusted to field conditions. This will be similar to the requirements for using a longitudinal float. The screed or screeds working ahead of the transverse float should carry a uniform roll of concrete so that the transverse float will leave a smooth uniform surface free of screed marks with a minimum of surging. Check that the cutting and smoothing operation is adequate and that the wheels are in constant contact with the side forms.

501.5.6.2 Hand Methods

Where hand methods of finishing are permitted, the surface should be floated with a hand-operated longitudinal float of specified size. It should be straight and of a rigidity to prevent flexing or warping. The float will be operated from foot bridges that span the entire width. The float will be worked in a sawing motion parallel to the centerline from one side of the pavement to the other. Each pass should overlap the preceding pass by not less than one-half the length of the float. Where it is necessary to smooth or fill in open-textured areas in the pavement surface after the preceding floating, it will be permissible to use an approved long-handle float. Care must be exercised in this operation to avoid distorting the surface. The use of this equipment should be limited to small areas and should not be used to float the entire surface. Excess water, laitance, and other foreign material will be wasted over the side forms on each pass.

501.5.7 Straightedging and Surface Correction

After the floating operation is complete and while the concrete is still in its plastic state, any excess water or laitance should be removed from the surface of the pavement with a straightedge 10 ft. (3 m) or more in length. Successive drags are to be lapped one-half the length of the blade. The surface must then be tested for trueness in the prescribed manner with a 10-ft. (3 m) straightedge that has been checked against a master straightedge. If high or low spots are observed, concrete will be added or removed and the area refinished and checked. Pay particular attention to the surface elevation across joints. The straightedge used for testing the surface should not be used for finishing or moving of concrete. Checking of the surface must continue until it conforms to grade and cross-section and is free of irregularities.

501.5.8 Surface Finishing Operation

Because of the damage caused to surface mortar by excessive water, especially where chemicals are used for snow removal, the use of water on the pavement or deck surface for the purpose of finishing must be strictly controlled. Require the Contractor to adjust the operation to provide a better and more timely finishing practice rather than wetting down the surface. If fogging or atomized misting is permitted where rapid drying occurs, pay particular attention to the operation to ensure proper control and prevent abuse. In slip-form operations, final finishing is generally performed by means of a secondary ironing screed, followed by an oscillating belt and a “V”-shaped, free floating, smoothing float. In lieu of this equipment, tamping bars followed by an extrusion plate and a transverse reciprocating belt may be used. The sliding forms attached to the paver must be rigidly held

together with lateral supports to prevent spreading. They will be of sufficient length so that no appreciable slumping of the concrete will occur and any necessary hand finishing can be accomplished while the concrete is still within the forms.

501.5.8.1 Surface Texturing

The surface of the mainline pavement, acceleration and deceleration lanes, ramps, and all travel lanes will be given a final groove finish, or texture. Wire combs consisting of flat steel spring tines, dimensioned according to the contract specifications, will be used to perform this task. Consider the following guidelines:

1. Equipment Checks. Before the operation, tines should be checked for conformance. In addition, tines should be checked periodically throughout the day to ensure they are not missing, worn, or out of shape. Hand brooms, approximately four feet wide, made of wire tines meeting specified requirements may be used in small inaccessible areas.

2. Timing. Texturing will begin when the concrete surface is of such plasticity as to allow texturing to the specified depth but dry enough to prevent the plastic concrete from flowing back into the grooves being formed.

3. Direction of Grooves. The texturing will be made in a transverse direction perpendicular to the centerline of the pavement.

4. Overlap. Adjacent strokes of the comb will abut one another without appreciable overlap.

5. Number of Passes. All texturing will be made with only one pass per surface area.

6. Superelevated Areas. Particular attention should be given where texturing in superelevated areas. It can be more difficult to obtain uniformity in these areas.

501.5.8.2 Edging at Forms and Joints

Before the concrete has taken its initial set, the edge of the pavement along each side of the slab and on each side of all formed joints, except joints initially formed that will be later widened by secondary sawing, will be rounded to their respective specified radius. Check that a well-defined and continuous radius is produced and a smooth, dense mortar finish is obtained. Care must be exercised to assure that the leg of the tool that is placed between the concrete and the form or joint is held vertical. Marks left on the pavement surface by edging may be removed by a wet paint brush or a small piece of damp burlap. Verify that any tool marks are eliminated without disturbing the radius. Any concrete splashed on top of joint filler material must be immediately removed. Ensure that all joints are checked with a straightedge before the concrete has set and the necessary corrections made if one side is higher than the other.

501.5.8.3 Application of Station Numbers

Before the concrete takes its final set, station numbers, dimensioned according the contract specifications, will be impressed on the pavement surface. Consider the following:

1. Location. Station numbers will be located every 100 ft. (20 m) and where equalities in alignment occur.

2. Placement/Orientation. The station numbers will be placed parallel to transverse joints, approximately 12 in. to 24 in. (300 mm to 600 mm) from the outside edge of the pavement in the following manner:

    a. Two-Lane Highway. Station numbers will be placed along the right edge of a two-lane highway, readable in the direction of increasing stations.

b. Multi-Lane Highway. On multi-lane highways, numbers will be placed along the outside edge of the two outside lanes of the roadway, readable in the direction of travel.

501.5.9 Removal of Forms

Where fixed-form paving operations are used, the forms must remain in place for a minimum of 12 hours after placement of the concrete, or longer as directed by the Project Engineer/ Supervisor. Good judgment must be exercised in making this determination because both weather and temperature affect the setting of concrete. The concrete should be allowed to harden sufficiently to minimize spalling and other damage upon removal of the forms. Immediately upon removal of the forms, check that the edges and sides are properly cured and all minor honeycombed areas are patched with mortar. Enforce the provisions of the Contract with respect to removal and replacement of major honeycombed areas.

501.5.10 Curing Methods and Procedures

The following Sections discuss topics that should be considered during the curing of Portland cement concrete pavements.

501.5.10.1 Curing Considerations

Unless specified otherwise in the Contract, the Contractor has the option of selecting from the various methods of curing that are presented in the **Standard Specifications** (e.g., burlap mats, waterproof paper, impervious membrane, polyethylene sheeting). Failure to provide adequate and acceptable curing is grounds for suspending the paving operation. Consider the following guidelines:

1. Timing. The curing operation for the entire width of the newly placed concrete must begin as soon as practical after the finishing operation without marring the newly textured surface. Timing is critical. The curing material must be applied before the surface begins to dry out. If left exposed to the sun and wind, surface moisture will rapidly evaporate and shrinkage cracks will begin to develop in the top portion of the slab.

2. Exposed Areas. Frequently, the curing material must be temporarily removed to perform other operations. Where removal is needed, the surface must not be left exposed for more than 30 minutes between stages of curing or during the curing period.

3. Water Usage. Where the method of curing requires the use of water, the curing operation will take precedence over any other operation demanding water on the project.

4. Cold-Weather Paving. During cold-weather paving operations (see Section 501.1.9.1), the curing period will be a minimum of seven calendar days, unless the Contractor adequately demonstrates that curing has been maintained for a minimum of 7,000 degree-hours. Verify that the surface temperature does not fall below freezing and enforce the provisions of the Contract with respect to removal and replacement of frost-damaged slabs.

501.5.10.2 Burlap Mats/Straw

Where this method is employed, water-saturated burlap mats will be used to cover the entire surface and both edges of the slab. The concrete surface must be firm enough to support the weight of the saturated burlap without marring. If placed prematurely, the burlap will sink into the concrete and mar the finish. Initial use of a curing compound will eliminate this problem (see Section 501.5.10.4). Check to ensure that the burlap mats are weighted to keep the material in contact with the concrete surface and maintained in a wet condition for a minimum of

72 hours after finishing. Straw is sometimes used in combination with burlap mats. Where straw is used, the burlap mats must remain for a minimum of 12 hours after finishing or until the concrete has taken its final set. After the burlap mats are removed, the entire surface will be thoroughly wetted and covered with a minimum of 8 in. (200 mm) of straw. This thickness of water-saturated straw must remain in place for a minimum of 72 hours after finishing. Where the straw is removed, check to ensure that it is not burned on or near the pavement, but disposed of properly off the right-of-way.

501.5.10.3 Waterproof Sheet Barriers

Waterproof sheet barriers include waterproof paper, white polyethylene sheeting, and polyethylene coated burlap. Before placement, the surface must be firm enough to support the weight of the material without marring and thoroughly wetted by means of a fine spray. The material must be of an approved type and be placed to cover the entire surface and edges of the slab. It is important that the material be weighted to ensure intimate contact with the surface, thus minimizing displacement and air pockets. Verify that the material is overlapped, sewn, or cemented at joints as necessary. The material must remain in place a minimum of 72 hours after finishing.

501.5.10.4 Impervious Membrane

Where white impervious membrane is used, the material will be applied over the entire surface and edges immediately after finishing or, where used in conjunction with burlap mats, immediately after the mats are removed. The membrane will be mechanically applied with equipment that will agitate the material to a uniform mixture within the tank and fully atomize the spray upon application at a rate of one gallon to not more than 125 ft^2. Hand spraying will be used where needed to ensure coverage. Frequently check and record quantities to ensure proper rate of application. Verify that the material is not applied inside the cavities of unsealed joints. In addition, the material is not to be applied in the rain. Enforce the provisions of the Contract with respect to repairing membrane damage. The material must remain in place a minimum of 72 hours after finishing.

501.5.11 Sawing Longitudinal Joints

Longitudinal joints will be cut normal to the surface of the pavement with a suitable concrete saw. Check to ensure that the depth and width of cut are within specified tolerance, and record these measurements. Consider the following guidelines:

1. Multi-Lane Construction. Where adjacent slabs are simultaneously constructed, the joint will be cut between 4 and 24 hours after concrete placement, depending upon weather conditions, and before any equipment is permitted to operate on the pavement. The joint then will be sandblasted to remove dirt, dust, and foreign matter. After sandblasting, rope or rod material, approximately 25% larger in diameter than the width of the joint, will be installed to keep the joint clean and dry. The rope or rod material will remain in place until just prior to sealing. At the time of sealing, the rope or rod material will be removed and discarded, and the joint will be cleaned with compressed air, prepared, and sealed as discussed in Section 501.5.13.

2. Lane-by-Lane Construction. Where adjacent slabs are constructed separately, the joint may be cut, sandblasted, cleaned with compressed air, and prepared just prior to sealing. If the joint is not sealed immediately after sawing, the joint will be sandblasted to remove dirt, dust, and foreign matter, and rope or rod material, approximately 25% larger in diameter than the width of the joint, will be installed to keep the joint clean and dry. The rope or rod material will remain in place until just prior to sealing. At the time

of sealing, the rope or rod material will be removed and discarded, and the joint will be cleaned with compressed air, prepared, and sealed as discussed in Section 501.5.13.

501.5.12 Sawing Transverse Joints

Transverse contraction and construction joints will be cut normal to the surface of the pavement with a suitable concrete saw. Check to ensure that the depth and width of these cuts are within specified tolerance and that the joint spacing conforms to the Contract Plans. Record these measurements. Unless otherwise approved, transverse joints will constructed in a two-step process. The joint will be initially established by either sawing or forming. If extreme conditions exist which make it impractical to prevent erratic cracking by initial sawing, the transverse contraction joints must be formed in the plastic concrete. Secondary sawing then will be performed to the final required dimensions of the joint.

501.5.12.1 Initial Sawing

Unless previously formed in the plastic concrete, all transverse contraction joints will be initially established by sawing. Consider the following guidelines:

1. Timing. It is critical to perform the initial sawing operation after the concrete has hardened sufficiently to prevent excess raveling but before uncontrolled shrinkage cracking begins. This range is generally within 4 to 24 hours after placement of the concrete. As needed, initial sawing should be performed continuously (i.e., day and night) regardless of weather conditions.

2. Raveling. Slight raveling is not objectionable and generally indicates that initial sawing is being performed at the proper time.

3. Location/Depth. Each joint must be cut over the center of the load transfer unit, within one inch of the dowels' mid-length, normal to the surface, and to the required depth for the full width of the slab.

4. Progression. The joints should be cut in a progressive manner. However, if uncontrolled cracking is observed ahead of the current sawing location, immediately move ahead and cut a joint ahead of the cracking. Once a joint has been cut at this forward location, return to saw the joints that were skipped. See Section 501.5.12.3 for information on random cracking.

5. Application of Rope or Rod. After initial sawing, rope or rod material, approximately 25% larger in diameter than the width of the joint, will be installed. The material must be of an approved type and completely encase the joint cavity (i.e., installed along the top, flush with the surface, and down the edge to the bottom of the joint). The material will remain in place until just prior to secondary sawing (see Section 501.5.12.2).

501.5.12.2 Secondary Sawing

Regardless of the method used to initially establish the transverse contraction joints (i.e., either initial sawing or forming), secondary sawing will be performed to establish a smooth and uniform joint face within tolerance of the full width and depth specified in the Contract. Any needed repair work will be performed at the Contractor's expense. Consider the following guidelines:

1. Timing. The rope or rod material will be removed and discarded and the secondary sawing operation will be immediately performed no earlier than 72 hours after concrete placement.

2. Sandblasting. After secondary sawing, each joint will be sandblasted to removed dirt, dust, and foreign matter from the faces of

the joint. A clean, dry, newly exposed concrete surface is necessary to ensure positive bonding of the joint sealant.

3. Joint-Face Irregularities. Upon completion of the sandblasting operation, inspect the joint faces for irregularities (e.g., spalled, cracked, and honeycombed areas; loose and unsound concrete). If left untreated, such irregularities will prevent proper bonding of the joint sealant. Check to ensure that loose, unsound concrete is removed and irregularities are repaired in an acceptable manner.

4. Excessively Wide Joints. Where a joint is found to be wider than specified tolerance and the excessive width can be attributed to inaccurate sawing rather than slab contraction, the width may be reduced by applying an acceptable epoxy-resin mortar mix to the vertical faces of the joint. This treatment is especially important where elastomeric seals are used. The joint faces must be clean and dry at the time the epoxy-resin mortar mix is applied. Alternatively, the Contractor may saw the joint opening wide enough to accommodate the next larger standard size of elastomeric joint seal.

5. Application of Rope or Rod. Where sealing does not commence immediately after secondary sawing, rope or rod material, approximately 25% larger in diameter than the width of the joint, will be installed. The material must be of an approved type and completely encase the joint cavity (i.e., installed along the top, flush with the surface, and down the edge to the bottom of the joint). The material will remain in place until just prior to sealing. At the time of sealing, the rope or rod material will be removed and discarded, and the joint will be cleaned with compressed air, prepared, and sealed as discussed in Section 501.5.13.

501.5.12.3 Random Cracking

Treatment of random cracking will be performed at no additional cost to the Division. Consider the following guidelines where random cracks are observed:

1. 3 in. (75 mm) from Dowel. Random cracks that develop within 3 in. (75 mm) of the dowels' mid-length will be immediately cut to the full width and depth as discussed in Section 501.5.12.2. The cut will be cleaned, prepared, and sealed with silicone sealant as discussed in Section 501.5.13.

2. 3 in. (75 mm) to 10 ft. (3 m) from Dowel: One Side. If a random crack develops within 3 in. (75 mm) to 10 ft. (3 m) of the dowels' mid-length, the cracked slab will be removed and replaced for a distance of 10 ft. (3 m) from the dowels' mid-length. The new joint will initially be established with a removable insert or by initial sawing (see Section 501.5.12.1). Secondary sawing will be performed as discussed in Section 501.5.12.2. The joint will be cleaned, prepared, and sealed as discussed in Section 501.5.13.

3. 3 in. (75 mm) to 10 ft. (3 m) from Dowel: Both Sides. If random cracks occur on both sides of a joint within 3 in. (75 mm) to 10 ft. (3 m) from the dowels' mid-length, the entire dowel assembly and the cracked slab will be removed and replaced for a distance of 10 ft. (3 m) on both sides of the dowels' mid-length. The new joint will initially be established with a removable insert or by initial sawing (see Section 501.5.12.1). Secondary sawing will be performed as discussed in Section 501.5.12.2. The joint will be cleaned and sealed as discussed in Section 501.5.13.

501.5.13 Joint Sealing Methods and Procedures

The following Sections discuss topics that should be considered during the sealing of joints in Portland cement concrete pavements.

501.5.13.1 Joint Sealing Considerations

Consider the following guidelines where longitudinal and transverse joints are sealed:

1. Timing. As soon as practical after curing, longitudinal and transverse joints will be sealed before the lane or lanes are opened to construction or public traffic.

2. Temperature. It is not permissible to seal joints where the temperature of the air or pavement surface is less than 40°F (5°C). Closely monitor temperature during cold-weather paving operations.

3. Cleaning and Drying. After joints are established to final dimensions (i.e., either formed or cut as specified), the faces and cavity of the grooves must be thoroughly cleaned and dried before sealing. Wire brushing, sandblasting, and high-pressure water are generally used for initial cleaning. Just prior to sealing, any rope or rod material that has been placed to prevent contamination will be removed and the joint cleaned and dried with compressed air to remove all fine dust, loose particles, and any residual debris. Verify that the compressor does not introduce oil or moisture into the joint.

4. Transverse Joints. Transverse contraction and construction joints typically require the installation of a preformed elastomeric seal and application of silicone sealant.

5. Longitudinal Joints. Longitudinal joints typically are sealed with silicone sealant.

501.5.13.2 Silicone Sealant Application

Consider the following guidelines where joints are sealed with silicone sealant:

1. Primer Application. The vertical surfaces of the joints will be primed if recommend by the sealant manufacturer. The primer material, its application, and safety precautions will conform to the manufacturer's recommendations. Where used, verify that the primer is allowed to dry tack-free prior to the installation of the back-up material.

2. Back-Up Material. Backer rod is generally used for back-up material. The Contract Plans will designate the required depth of placement. Verify that the backer rod is being installed in the joint at the required depth.

3. Application of Sealant. Silicone sealant should never be applied to frozen, dirty, wet, or damp concrete or during inclement weather. Verify that the sealant is applied (e.g., poured) into the cavity above the backer rod to the dimensions required by the Contract Plans. Check to ensure that the sealant is being tooled to force the sealant to completely wet the vertical faces of the joint and to provide a slightly concave surface of specified dimensions below the pavement surface. Enforce the provisions of the Contract with respect to removal and replacement of unacceptable joint seals. Require the Contractor to immediately clean any sealant material spilled on the exposed surface of the pavement above the joint.

501.5.13.3 Preformed Elastomeric Seal Installation

Consider the following guidelines where preformed elastomeric seals are used:

1. Elastomeric Seal Material. The elastomeric seal material must be one-piece of an

approved material type preformed to the dimensions required by the Contract Plans and Specifications in terms of cross-section, width, and depth of installation with the joint cavity. Splicing of the material is not permitted.

2. Lubricant-Adhesive Application. Just prior to installation of the elastomeric seal, verify that lubricant-adhesive material is applied consistent with the manufacturer's recommendations. In general, the lubricant-adhesive material will be applied to the vertical faces of the joint, the sides of the seal, or both as needed to facilitate installation without damage and to ensure a positive seal between the joint face and the elastomeric material.

3. Installation of Seal. Where elastomeric seals are installed to the depth specified in the Contract Plans, the material will be substantially compressed in the direction normal to the sides of the seal. Verify that the seals are installed without damage and within tolerance of specified elongation. From practical experience, elastomeric joint seals are better installed slightly lower than planned elevation rather than higher. If installed too high, the seal will be exposed to traffic during compression cycles and damaged. Any residual or spilled lubricant-adhesive material on top of the seal or the pavement surface above the joint must be immediately removed. Enforce the provisions of the Contract with respect to removal and replacement of damaged seals and unacceptable installation.

See Section 624 of the **Standard Specifications** for additional information.

501.6 PAVEMENT WIDENING

Where it is necessary to widen one or both sides of an existing Portland cement concrete pavement, the guidelines in Sections 501.1 through 501.5 apply except as follows:

1. Grade Compaction. Compaction of the fine grade may be by means of an approved special roller capable of exerting a compressive force of not less than 100 lbs./in. (1.8 kg/mm) of width (see Section 207.9 of the **Standard Specifications**).

2. Forms. Forms may be made of steel or wood, and they will be secured as required by the Project Engineer/Supervisor.

501.7 RECORDS AND DAILY REPORTS

Project Inspectors at the mix production site and the paving site must ensure that accurate and complete records are maintained for the final project records. The Inspector's Daily Report and its pertinent attachments must include the routine and non-routine events that occur during each production and paving day and reflect an unquestionable basis for acceptance or rejection. Many claims and lawsuits have been settled based on such documentation where deficiencies in test results and pavement performance have developed. Attempting to reconstruct events later without written notes and test data is frustrating and often leads to conflicts. Use the Division's Form 442, and pertinent attachments, to prepare the Supervisor's and Inspector's Daily Reports. If in doubt as to whether or not information is important or beneficial, write it down.

501.7.1 Production Records and Reports

The Project Inspector at the production site is responsible for enforcing the provisions of the Contract with respect to compliance and acceptance of raw materials and the PCC mix. The Project Inspector should be familiar with the source and type of aggregate intended for use, mix proportions, moisture content, method of determining scale weights, mixing equipment and operation, required control and acceptance tests, and reports, as discussed in Sections 501.1 and 501.2. Consider the following when preparing the Inspector's Daily Report:

1. date and Project Inspector's name;
2. project number and location;
3. item number and description;
4. weather and temperature conditions;
5. source of materials, including laboratory numbers;
6. method and time of production;
7. information from the PCC Mix Design Plan;
8. times of plant scale checks;
9. aggregate gradation, cement content, moisture, and other test results;
10. proportions of each material used (e.g., aggregate, cement, water, admixtures);
11. results of mixing time checks;
12. daily quantity of mix produced;
13. hauling method, equipment, and time of loading;
14. location on pavement where daily production was placed;
15. date, time, location of samples taken and name of technician;
16. procedure used to measure mix properties;
17. tests conducted or observed, results, and any corrective action taken;
18. material or mix rejected and disposition;
19. instructions given to Contractor. or received from Project Engineer/Supervisor;
20. visitors and their comments and agreements;
21. remarks, unusual occurrences, lost time due to breakdowns, or test results failing the contract specifications including corrective action, changes to mix proportions, plant operation, and test procedures;
22. number of inspection hours for the day; and
23. signatures of appropriate personnel.

501.7.2 <u>Paving Records and Reports</u>

The Project Inspector at the paving site is responsible for enforcing the provisions of the Contract with respect to compliance and acceptance of the constructed pavement. The Project Inspector should be familiar with the Contract Plans and Specifications, pre-paving operations, paving equipment requirements, methods of construction, control and acceptance tests, and reports, as discussed in Sections 501.3 through 501.5. Consider the following when preparing the Inspector's Daily Report:

1. project number and location;
2. weather conditions;
3. subgrade/subbase measurements;
4. type and make of equipment and adjustment checks;
5. water used and mixing time checks;
6. results of slump, entrained air, and other tests;
7. installation of tie bars and hook bolts;
8. alignment and grade of dowel baskets;
9. location of keys and flares;
10. type and quantity of mix placed;
11. thickness, lane, and station number;
12. depth of reinforcement;

13. vibrator and tamper checks and consolidation results obtained;

14. results of finished crown and straightedge checks;

15. curing application method and period;

16. depth and width of joints;

17. joint sealing operation checks;

18. location, time, date, and reason for sampling;

19. unusual events, conditions, or test results;

20. failing test results, explanation, steps taken for correction, and results;

21. changes made in production or paving operations or equipment;

22. visitors to the site and their comments;

23. reason for delays in paving (e.g., equipment breakdown, poor weather);

24. discussions with the Contractor, including instructions and directives given; and

25. signatures of appropriate personnel.

501.8 MEASUREMENT FOR PAYMENT

The contract unit price will be used for full compensation for all labor, materials, and equipment necessary to complete the work. Consider the following guidelines:

1. PCC Pavement. Portland cement concrete pavement will be paid for based on the number of square yards (square meters) of pavement placed and accepted as determined from the width and centerline length of mainline and ramps designated on the Contract Plans. Include the area of any additional widening as approved by the Project Engineer/Supervisor.

2. Bridge Approach Expansion Joints. Bridge approach expansion joints will be measured separately and will be based on the actual number of joints constructed and accepted.

3. Pavement Widening. Strips of concrete pavement for pavement widening projects will be paid for based on the number of square yards (square meters) placed and accepted as determined from actual field measurements.

4. Recycled Pavement. Do not pay separately for removing and crushing existing concrete pavement for use as coarse aggregate in the new PCC mix.

5. Payment Adjustment. Where the average value of pavement thickness, as determined from analyzing pavement core measurements, is less than that specified for full compensation, enforce the provisions of the Contract with respect to deductions and complete removal and replacement.

Section 502

APPROACH SLABS

502.1 GENERAL

To minimize the bump on the roadway surface caused by the settlement of backfill material behind bridge abutments, most bridge designs call for heavily reinforced concrete slabs at both ends of the structure, called approach slabs.

502.1.1 Description of Work

The work for approach slabs generally consists of the construction of specially designed reinforced concrete slabs at the approaches to bridge structures. Construction details will be designated in the Contract Plans and Specifications. It is the responsibility of the Project Inspector to ensure that the Contractor is in reasonable conformance with specified requirements.

502.1.2 Material Requirements

Materials requirements for the construction of approach slabs generally conform to those discussed in Sections 501.1.3 and 501.1.4 of this **Manual** with the following exceptions:

1. Concrete. Class B structural concrete, as specified in Section 601 of the **Standard Specifications**, may be used in lieu of Section 501 of the **Standard Specifications**.

2. Compressive Strength Acceptance Testing. Use the compressive strength testing procedures for structural concrete, as specified in Section 601 of the **Standard Specifications**, to determine acceptability.

3. Forms. Side forms may be made of steel or wood.

4. Reinforcing Steel. Unless otherwise specified, the requirements for reinforcing steel will be governed by Section 602 of the **Standard Specifications**.

502.1.3 Other Considerations

Review Section 501.1 of this **Manual** for other general topics that should be considered during the project.

502.2 CONSTRUCTION OPERATIONS

Construction methods and equipment used to construct approach slabs will be as described in Section 501 of this **Manual** except as modified in the following Sections.

502.2.1 Backfill and Base Course Compaction

Prior to placement of the approach slab, check to ensure that the backfill material and the base course material have been properly constructed and compacted to the target density. During construction, pay particular attention to the lift thickness, moisture content, and the density obtained for each lift. Achieving target density in these areas with a uniformly constructed and compacted material cannot be overemphasized. Poor construction methods during this operation will invariably cause voids and settlement, and this is the primary cause of pavement failures at bridge approaches.

502.2.2 Setting of Forms

Check to ensure that the forms have been properly set for the required grade and cross-section of the Contract Plans. The final grade of

the approach slab is controlled by the bridge deck and the roadway pavement.

502.2.3 Paving Notch Construction

Each approach slab will rest on a shelf (i.e., paving notch), which is formed in the backwall of the abutment and the uniformly compacted backfill and base course materials. Verify that the construction of the paving notch conforms to the requirements of the Contract Plans and Specifications.

502.2.4 Reinforcement and Keys

The reinforcement for approach slabs consists of an upper and lower mat of reinforcing bars. Verify that the lower mat of bars is supported, see Section 501.1.4.2, at least two inches above the surface of the compacted and finished base course, unless otherwise specified. The approach fill end will have keys which act as a load transfer joint between the slab and pavement. Check to ensure that these keys conform to the requirements of the Contract Plans.

502.2.5 Expansion Joints

An expansion joint, meeting the specified requirements for preformed joint material, will be placed between the end of the approach slab and the backwall of the abutment. Verify that the expansion joint material is of an approved type, and check to ensure that the preformed joint material is properly placed and secured.

502.2.6 Placement of Concrete

Check to ensure that the base course, or subgrade, is thoroughly moistened immediately prior to the placement of concrete. The sequencing of the concrete pour is typically specified in the Contract Plans or directed by the Project Engineer/Supervisor. Verify that this sequence is actually performed.

502.2.7 Consolidation of Concrete

Check to ensure that hand vibrators are used to thoroughly consolidate the concrete around the reinforcement and imbedded fixtures and into the corners and angles of the forms.

502.2.8 Curb Construction

Curbs will be constructed using the same type of concrete as for the approach slab and will be in accordance with the Contract Plans. Verify that the curb is finished in accordance with Section 610 of the **Standard Specifications**. See Section 610 for additional information.

502.2.9 Form Removal

Verify that forms are not removed for least 24 hours after the concrete has been placed, or as otherwise directed by the Project Engineer/Supervisor.

502.2.10 Joint Construction

Sawing will be performed within five days after the slab is placed and prior to opening to any traffic. Verify that the longitudinal joints of the approach slabs are in line with the longitudinal joints of the adjacent pavement slabs. Check that longitudinal joints are cut by sawing ¼ in. (6 mm) greater than one-fourth of the slab depth designated in the Contract Plans. Verify that the width of the cut groove is ¼ in. (6 mm), plus or minus 1/16 in. (2 mm). See Section 501.5.13 for information on sealing joints.

502.3 RECORDS AND DAILY REPORTS

See Section 501.7 for applicable guidance on maintaining project records and Inspector's Daily Reports.

502.4 MEASUREMENT FOR PAYMENT

The quantity of work completed and accepted will be measured in square yards (square meters) based on the area designated in the Contract Plans. The Contract unit price will be used for full compensation for all labor, materials, and equipment to construct the approach slabs.

Section 503

SEALING JOINTS AND CRACKS IN CONCRETE PAVEMENT

503.1 GENERAL

The intrusion of moisture and incompressible material into joints and cracks will invariably cause the concrete slabs to spall, settle, heave, or buckle due to the softening or removal of underlying material (e.g., base, subgrade), pumping action of the slabs, freeze-thaw action, and corrosion of dowels. Sealing of joints and cracks in new construction and rehabilitative work is performed as a preventative measure to ensure a longer pavement life. A condition survey usually will be performed to determine the need seal cracks and joints in rehabilitation projects.

503.1.1 Description of Work

This work generally consists of cleaning and sealing joints and cracks in the concrete pavement. It is the responsibility of the Project Inspector to ensure that the work is performed consistent with the requirements of the Contract Plans and Specifications.

503.1.1.1 New Construction

On new construction projects, longitudinal and transverse joints will be established by either sawing or forming, depending on the requirements of the Contract and the Project Engineer/Supervisor. See Sections 501.5.2 and 501.5.11 for information on longitudinal joints and Sections 501.5.3 and 501.5.12 for information on transverse joints and random cracking. The joints and any random cracks that may develop in the new pavement must be properly cleaned and sealed before the lane or facility is opened to any traffic (see 501.5.13).

503.1.1.2 Rehabilitation

Rehabilitative work on concrete pavements typically includes provisions for sealing existing longitudinal and transverse joints and any cracks that have developed in the pavement. It is one of the final steps of a rehabilitation project and is typically performed after undersealing, pavement jacking, diamond grinding, and other major rehabilitative activities. It is very important that the slabs be stable for the new seal to function properly. The sealing operation is generally the same as that used for new construction with one important exception. The preparatory operation will include provisions for the removal of all existing sealant materials before thoroughly cleaning and resealing the joints (e.g., backer rod, silicone sealant, preformed expansion joint material).

503.1.2 Material Requirements

See Section 501.1.4.6 for information on the materials typically used to seal joints and cracks.

503.1.3 Other Considerations

Review Section 501.1 of this **Manual** for other general topics that should be considered during the project.

503.2 EQUIPMENT CONSIDERATIONS

Equipment that is typically used to place heated sealant material includes conventional hand pouring pots, individual wheel-mounted pouring kettles with pouring shoe, and heating units from which the material may be discharged through a flexible line and pouring shoe. Before the sealing operation begins, verify the acceptability

of the equipment with respect to type, number, and maintenance. The equipment used must be able to uniformly heat the material to the correct temperature and accurately control the pouring of the sealant. Direct or localized heating of the material is unacceptable. Verify that the heating kettle is equipped for indirect and uniform heating (e.g., double boiler).

503.3 CONSTRUCTION OPERATIONS

The following Sections discuss topics that should be considered with respect to the joint and crack sealing operation.

503.3.1 Sealant Preparation

Before the raw sealant material is placed into the heating kettle, check to ensure that the kettle is clean and free from residual and foreign materials. Monitor the temperature of the sealant for compliance with the supplier's recommended temperature. Do not allow the use of any sealant material that exceeds the maximum recommended temperature. Ensure that discarded sealant is disposed of properly.

503.3.2 Joint and Crack Preparation

Sawing may be needed to reestablish the dimensions of existing joints and widen cracks. All joints and cracks must be thoroughly clean and dry prior to sealing. Otherwise, the sealant material will not bond to the exposed surface of the concrete. Verify that all dirt, dust, loose and foreign materials are removed from the cavity. A combination of hand and power tools are generally used to perform this task (e.g., sandblaster, rotary brushes, water jet). If the cavity is not immediately sealed, rope or rod may be used to minimize contamination after initial cleaning. Just prior to sealing, ensure that joints and cracks are blown out with compressed air and that the exposed faces of the cavity are primed as specified. Where used, check that backer rods and preformed elastomeric seals are properly installed. See Section 501.5.13 for additional information.

503.3.3 Sealing Operation

See Section 501.5.13 for guidance on sealing joints in Portland cement concrete pavements. Consider the following additional guidelines:

1. Timing. As practical, joints and cracks should be sealed the same day they are prepared; otherwise, consider the use of rope or rod to minimize contamination. This prevents unnecessary intrusion of moisture, dust, and incompressible materials in the cavity.

2. Moisture/Temperature. The sealant material will not be poured in joints or cracks that are either dirty or wet. If the joints and cracks are wet or damp or if the ambient temperature is below the minimum specified for application, suspend the work until the conditions are favorable.

3. Depth of Pour. Verify that joints and cracks are filled to within ¼ in. (6 mm), plus or minus 1/16 in. (2 mm), of the pavement surface. In new construction, check that the sealant is poured to the depth specified in the Contract Plans. In rehabilitative work, the sealant will be poured to the full depth of the cavity.

4. Pouring Shoes. Where pouring shoes are used, which overlap the pavement surface adjacent to the joint, verify that the resultant strip of sealant material is neat and straight. Require removal of excess sealant from the pavement surface. As needed, enforce the provisions of the Contract with respect to removal and replacement of unacceptable work.

5. Spills. Verify that any spills on the pavement surface are immediately removed.

6. Traffic. Traffic should not be permitted on the pavement until after the joints and cracks have been properly sealed. In addition, the sealant should be allowed to cure sufficiently to prevent damage prior to opening to traffic.

503.4 RECORDS AND DAILY REPORTS

See Section 501.7 for applicable guidance on maintaining project records and Inspector's Daily Reports.

503.5 MEASUREMENT FOR PAYMENT

The quantity of work completed and accepted will be measured in linear feet (meters) based on field measurements and the Contract Plans, as applicable. The Contract unit price will be used for full compensation for all labor, materials, and equipment to seal the joints and cracks.

Section 504

BITUMINOUS UNDERSEAL FOR CONCRETE PAVEMENT

504.1 GENERAL

During the life of a concrete pavement, water can infiltrate the subsurface and cause settlement or displacement of the base or subgrade material, which can create voids under the slabs. If left untreated, the slabs may eventually fault at joints. Where field tests indicate the presence of voids, undersealing is specified to fill the voids before faulting occurs. Where the voids have enlarged to the extent that faulting is evident, undersealing is specified to both fill the voids and raise the slab back to grade (i.e. pavement jacking), thus reestablishing the pavement profile and cross-section. Pavement jacking is generally specified in lieu of full-depth patching where the pavement is not badly cracked or deteriorated.

504.1.1 Description of Work

This work generally consists of drilling holes in the Portland cement concrete pavement at the locations designated in the Contract Plans, or as otherwise directed by the Project Engineer/ Supervisor, pumping bituminous material through the holes, and refilling the holes with cement ground. It is the responsibility of the Project Inspector to ensure that the work is performed consistent with the requirements of the Contract Plans and Specifications.

504.1.2 Materials Requirements

The materials requirements for bituminous undersealing will be governed by Section 504 of the **Standard Specifications**. The non-shrink grout for refilling core holes will meet the requirements of Section 715.5 of the **Standard Specifications**. Contact the Materials Control, Soil and Testing Division for a list of acceptable grout materials

504.1.3 Weather Limitations

Do not allow the bituminous undersealing operation to be performed where the underlying subgrade or base is frozen, nor where the ambient temperature is below 40°F (5°C) and is falling. If there is any doubt as to the suitability of the weather conditions to perform this operation, discuss the matter with the Project Engineer/Supervisor.

504.1.4 Hazards

In general, construction sites pose many hazards. The bituminous undersealing operation, in particular, should be performed with extreme care. High pressure will be used to pump 400°F (205°C) bituminous material into cavities under the concrete pavement. If for example, the nozzle is pulled out of the drill hole prematurely, the hot material could backflow and spray out in all directions. In addition, although infrequent, a blowout at the edge of the pavement could occur. Personnel performing this operation should be on constant alert to these possibilities and pay particular attention where they are standing in close proximity to the injection site.

504.1.5 Other Considerations

Review Section 501.1 of this **Manual** for other general topics that should be considered during the project.

504.2 EQUIPMENT CONSIDERATIONS

The bituminous undersealing operation generally requires the following types of equipment:

1. tank or container sufficient in capacity and operation to indirectly heat and mix the necessary quantity of bituminous material to a uniform consistency and temperature of 400°F (205°C);

2. positive displacement pump capable of developing adjustable pressures up to 80 lbs/in^2 (550 kPa), including all necessary gauges, valves, hoses, and nozzles;

3. air compressor, drill, and 1½ in. (40 mm) diameter concrete coring bits for the drilling operation;

4. pavement movement detection equipment;

5. tools necessary to refill drill holes with non-shrink grout; and

6. cleanup tools and materials and water tankers and service trucks.

504.3 CONSTRUCTION OPERATIONS

The following Sections discuss topics that should be considered with respect to the bituminous undersealing operation (i.e., subsealing or pavement jacking).

504.3.1 Drilling Operation

Bituminous undersealing operations require that 1½ in. (40 mm) diameter holes be drilled in the pavement to inject the heated bituminous material under the surface. The drill hole location, spacing, and depth will either be designated on the Contract Plans or directed by the Project Engineer/Supervisor. Field experimentation may be required to determine an effective pattern Verify that holes are being drilled as specified and that the drill speed is being closely monitored to avoid spalling out of the drill hole on the underside of the pavement. Consider the following additional guidelines.

1. Subsealing Application. Where a treated base supports the pavement, drilling through the pavement, but not through the treated base will usually be necessary. This allows the pumping of the bituminous material to fill the voids between the base and the pavement. For untreated bases, multiple pumping operations may be needed, depending on the viscosity of the bituminous material and the character of the untreated base material.

2. Pavement Jacking Application. The drill hole pattern will usually differ from that used for subsealing applications. Where a treated base supports the pavement, it will usually be necessary to drill the hole through the pavement and the base.

504.3.2 Surface Preparation

Prior to the pumping operation, the surface of the concrete pavement around the drill holes will be thoroughly sprinkled with water. Optionally, the area may be covered with sand, earth, or other suitable material to prevent bonding of any spilled bituminous material on the pavement surface.

504.3.3 Bituminous Material Preparation

Just prior to pumping, verify that the bituminous material is being monitored with respect to temperature and uniformity. The Contractor is responsible for heating the material to a uniform temperature of not less than 400°F (205°C). Localized or direct heating will not be permitted. The bituminous material can be less fluid for pavement jacking applications than for subsealing applications, especially where pumping in a hole for the second or third time.

504.3.4 Pumping Operation

After the material has been heated to the required temperature and the holes have been properly drilled, the pumping operation will begin. The methods and working pressure for the undersealing operation will depend on the type of operation (i.e., subsealing or pavement jacking) and will be either specified in the Contract or directed by the Project Engineer/ Supervisor. Pavement jacking applications typically require a higher pressure.

504.3.4.1 Subsealing Applications

A drill hole will be selected and the nozzle will be inserted in the hole, driven to a snug fit, and the pumping operation begun. The bituminous material will be pumped under pressure through the hole until the void under the pavement is completely filled. Verify that the slab is being properly monitored for undesirable movement. A level, stringline, or Benkleman Beam are commonly used for this purpose. At the first sign of slab movement or a blowout, the pumping will immediately be stopped. The nozzle should not be removed until the material has cooled sufficiently to prevent backflow onto the pavement surface.

504.3.4.2 Pavement Jacking Applications

The pumping of the bituminous material should begin at the hole at the lowest point of the dip or settlement of the slab. The nozzle will be inserted in the hole, driven to a snug fit, and the pumping operation begun. Where a treated base supports the pavement, the nozzle should be inserted so that the material will be injected under the treated base, and not just fill any voids between the slab and the treated base. The bituminous material will be pumped under pressure through the hole until the slab has been raised to the grade of the adjacent slab or as otherwise directed by the Project Engineer/ Supervisor. Verify that slab movement is being properly monitored. A level, stringline, or Benkleman Beam are commonly used for this purpose. Constant attention must be given to controlling the movement of pavement in small increments. Too much pressure may cause rapid movement of the slab, radial cracking at the drill hole, undesirable movement of the shoulder, blowouts outside the shoulder, and infiltration of existing underdrains. The nozzle should not be removed until the material has cooled sufficiently to prevent backflow onto the pavement surface.

504.3.5 Cleanup

After the pumping operation has been satisfactorily completed, verify that all bituminous material that may have bonded to the pavement surface has been properly cleaned and that the drill holes have been filled with non-shrink grout to an elevation flush with the pavement surface.

504.4 RECORDS AND DAILY REPORTS

See Section 501.7 for applicable guidance on maintaining project records and Inspector's Daily Reports.

504.5 MEASUREMENT FOR PAYMENT

The quantity of work completed and accepted will be measured as the number of gallons (liters) of bituminous material injected and number of holes drilled and refilled. The Contract unit price will be used for full compensation for all labor, materials, and equipment necessary to perform the undersealing operation.

Section 506

CONCRETE PAVEMENT REPAIR

506.1 GENERAL

Concrete pavement repair in Section 506 of the **Standard Specifications** specifies full-depth patching, which is typically used to repair severely cracked concrete pavement slabs; joint spalling where the spalling extends below the mid-depth of the slab; D-cracking, corner breaks, and joint faulting where the condition cannot be remedied by partial-depth patching, subsealing, or pavement jacking. If the pavement rehabilitation project specifies diamond profile grinding, full-depth patching typically is performed before the grinding operation. Areas to receive full-depth patching will be designated on the Contract Plans. The patches typically extend across the full width of the deteriorated slab and may include the full length between transverse joints, a partial section between joints, or a section centered around a transverse joint. The minimum length of the patch should typically not exceed 10 ft. (3 m).

506.1.1 Description of Work

506.1.1.1 Full-Depth Patching

The work for full-depth patching generally consists of removing and replacing deteriorated concrete pavement sections to the full depth of the slab and at the locations and plan dimensions as specified in the Contract, or as otherwise directed by the Project Engineer/Supervisor. Pay particular attention to how reinforcement, where applicable, is to be reestablished for the patched section. It is the responsibility of the Project Inspector to ensure that the work is performed consistent with the requirements of the Contract Plans and Specifications.

506.1.1.2 Partial-Depth Patching

Partial-depth patching is used to repair spalls, potholes, and other minor surface defects. Major spalls (i.e., below mid-depth of slab) and cracks that extend through the entire slab generally will require full-depth patching. The depth of partial-depth patching is typically one-third the slab depth, unless otherwise directed. If the Contract also specifies diamond profile grinding and undersealing, partial-depth patching is generally performed first. Where partial-depth patching is specified, the Project Inspector is responsible for ensuring that the work is consistent with the requirements of the Special Provisions of the Contract. Partial-depth patching is similar to full-depth patching, as discussed in Section 506, except as follows:

1. Removal of Deteriorated Concrete. The width, length, and depth of the saw cut around the perimeter of the patch area will be only as deep as the dimensions of the patch specified. To prevent damage to the adjacent sound concrete, a relatively lightweight pneumatic hammer is often used to break and remove the deteriorated concrete; however, a milling machine is sometimes used if the area is large enough to justify the use such equipment. The bottom of the area to be patched should be approximately parallel with the pavement surface. Cuts beyond patch limits or across joints will be sealed with epoxy cement, or other approved material.

2. Preparation of Patch Area. All loose concrete particles, dust, and oil must be removed by sandblasting and compressed air, or other suitable means. Just prior to concrete placement, a bonding agent will be applied to the bottom of the patch area and other exposed surfaces that will come into

contact with the new concrete patch material. Faces of joints and working cracks will not receive this treatment.

506.1.2 Material Requirements

Verify that the materials used for concrete pavement repair are from an approved source and conform to the provisions of the Contract (see Section 506.2 of the **Standard Specifications**). Specifically note the requirements for using Portland cement concrete, structural concrete, accelerating admixtures. and epoxy grout for anchoring dowel bars. Joint sealant will be of the hot-poured type meeting the requirements of Section 708.3 of the **Standard Specifications.**

506.1.3 Quality Acceptance Considerations

The following Sections discuss topics that should be considered with respect to the Division's responsibilities for quality acceptance.

506.1.3.1 Compressive Strength Evaluation for Opening to Traffic

Slabs that receive full-depth patching may be put into service when representative test specimens indicate that the concrete used for the patches has attained a compressive strength of 2000 lbs/in^2 (13.8 MPa).

506.1.3.2 Surface Smoothness Evaluation for Acceptance

Surface smoothness will be evaluated for acceptance based on the procedures defined in Section 506.8 of the **Standard Specifications**. Enforce the provisions of the Contract with respect to removal and replacement of unacceptable work.

506.1.4 Protection of Pavement

Check for damage to pavement and shoulder areas adjacent to the patching location. Damage sometimes is caused by the concrete removal process and the concrete-placing equipment. Enforce the provisions of the Contract with respect to repairing such damage.

506.1.5 Other Considerations

Review Section 501.1 of this **Manual** for other general topics that should be considered during the project.

506.2 EQUIPMENT CONSIDERATIONS

Many types of equipment are used to perform full-depth patching. Concrete saws and blades, jack-hammers, drop-hammers, and lifting equipment are used to remove the deteriorated concrete. Conventional hand-operated concrete construction equipment and tools are used to place, finish, and cure the full-depth patch. See Section 503.2 for information on the equipment typically used for hot-poured joints sealant. Verify that the equipment used conforms to specified requirements or directives.

506.3 CONCRETE PRODUCTION

Portland cement concrete, as specified in Section 501 of the **Standard Specifications**, is generally used for full-depth patching. See Section 501.2 of this **Manual** for additional information. On projects where the concrete will be overlaid with hot-mix asphalt (see Section 401), the Contractor may optionally use structural concrete as specified in Section 601 of the **Standard Specifications**. Before the patching operation begins, verify that the Contractor has submitted for review the required Mix Design Plan and compressive strength test data.

506.4 PRE-PATCHING OPERATIONS

The following Sections discuss topics that should be considered with respect to pre-patching operations.

506.4.1 Removal of Deteriorated Concrete

Prior to patching, the deteriorated concrete must be removed. The following two methods are typically used:

1. Lift-Out Method. To minimize potential damage to the sound concrete adjacent to and on the underside surface of the slab, as well as to the underlying base material, the lift-out-method is strongly recommended. The perimeter of the area to be removed will be cut full depth by saw. The section to be removed is then cut full depth into smaller sections that can be easily lifted with available equipment. Typically, one or more transverse cuts are double-sawed to minimize wedging when the sections are removed. Holes are drilled into the smaller sections to accommodate cables attached to the lifting equipment.

2. Chip-and-Break Method. In the chip-and-break method, the perimeter of the area to be removed will be cut full depth by saw. Equipment such as a jack-hammer or drop-hammer will be used to chip and break the deteriorated concrete within the cut perimeter. Broken pieces are generally removed by a combination of hand and machine methods. This operation must be carefully monitored to prevent damage to sound concrete adjacent to the slab and to minimize spalling of the underside of the pavement. The base also may be disturbed, which will require the removal of the loose material and replacement with acceptable base course material.

506.4.2 Preparation of Underlying Course

Investigate the underlying pavement course (e.g., base, subbase, subgrade) for acceptability in terms of moisture and density. Any underlying material that has been disturbed below the desired level of removal will be removed, replaced, and compacted based on the provisions of the Contract. If the disturbance is the Contractor's fault, no additional payment will be made. If excessively wet or soft base, subbase, or subgrade material is encountered, the problem will be corrected based on the requirements of the Project Engineer/Supervisor, which may include removal and replacement and underdrain installation.

506.4.3 Shoulder Preparation

After the deteriorated concrete has been satisfactorily removed and disposed of properly, verify that the resulting edges and the pavement-to-shoulder interface is tacked or prepared as required.

506.5 PATCHING OPERATIONS

The following Sections discuss topics that should be considered with respect to patching operations.

506.5.1 Joint Replacement

Where the full-depth patch will affect existing joints and joint materials, they must be inspected, repaired, or replaced in conformance with the Contract Plans and Specifications, or as otherwise directed by the Project Engineer/ Supervisor. Full-depth patches may require installation of load transfer devices (e.g., dowel assemblies). To accommodate expansion, working cracks should be treated similarly to transverse expansion joints. See Sections 501.5.2 and 501.5.3 for additional information on joint construction.

506.5.2 Placement of Reinforcing Steel

Check to ensure that reinforcing steel (e.g., mesh) is installed as specified or directed. See Section 501.5.4 for additional information.

506.5.3 Placement of Concrete

The concrete will be placed in the area to be patched using a metal chute. Check to ensure that the free fall of the concrete is limited to no more than 3 ft (1 m); otherwise, the material components will splatter and segregate. Hand methods will be used to distribute the concrete in the patch area. Rakes should not be used.

506.5.4 Finishing Operations

1. Strike-Off and Consolidation. After the concrete has been placed in the patch area, it will be struck-off to the appropriate profile and cross-section by approved hand methods (see Section 501.5.5.2).

2. Consolidation of Concrete. The concrete in the patch area must be consolidated to ensure that that area beneath the existing concrete pavement is completely filled. Hand-operated spud vibrators are typically used for this operation. See Sections 501.4.3 and 501.5.5.3 for additional information.

3. Floating Operation. The surface of the patch area will be floated to a smooth finish by approved hand methods. See Section 501.5.6.2 for additional information.

4. Straightedging and Surface Correction. Straightedging and surface correction will be performed to ensure a smooth riding surface in accordance with the provisions of the Contract (see Section 506.1.3.2 and Section 501.5.7 for additional information).

5. Final Finishing Operation. Final finishing should produce a profile and cross-section that matches that of the existing pavement, or as otherwise directed by the Project Engineer/Supervisor. The surface texture also should match that of the existing pavement surface. If stations numbers were with the perimeter of the area removed, ensure that that are properly reestablished. See Section 501.5.8 for additional information.

6. Removal of Forms. Any formwork used to construct the patch should be removed without damage to the pavement (see Section 501.5.9).

7. Curing Methods and Procedures. The methods and procedures for curing are discussed in Section 501.5.10 of this **Manual**. Pay particular attention to the methods employed where early opening to traffic is required.

8. Sawing and Sealing Joints. Where joints are affected, ensure that joints are properly cut by saw and sealed as specified or directed. See Sections 501.5.11 and 501.5.12 for information on joint sawing and Section 501.5.13 for information on joint sealing methods.

506.6 RECORDS AND DAILY REPORTS

See Section 501.7 for applicable guidance on maintaining project records and Inspector's Daily Reports.

506.7 MEASUREMENT FOR PAYMENT

The quantity of work completed and accepted will be measured as the number of square yards (square meters) of concrete pavement repair. The Contract unit price will be used for full compensation for all labor, materials, and equipment necessary to perform the patching.

Section 507

CRACK AND POTHOLE REPAIR

507.1 GENERAL

507.1.1 Description of Work

The work for crack and pothole repair generally consists of repairing an existing concrete pavement surface prior to resurfacing with hot-mix asphalt. It is the responsibility of the Project Inspector to ensure that the work is performed consistent with the requirements of the Contract Plans and Specifications, or as otherwise directed by the Project Engineer/Supervisor.

507.1.2 Material Requirements

The material requirements for crack and pothole repair are governed by Section 507.2 of the **Standard Specifications**. Before the work, verify that the Contract has supplied approved materials.

507.1.3 Other Considerations

Review Section 501.1 of this **Manual** for other general topics that should be considered during the project.

507.2 CONSTRUCTION CONSIDERATIONS

Prior to overlaying with hot-mix asphalt, all cracks and potholes must be repaired to the grade of the adjacent surface.

507.2.1 Small Cracks

Cracks greater than 1 in. (25 mm) but less than 3 in. (75 mm) in width will be treated in the following manner:

1. Preparation. Verify that the cracks are thoroughly cleaned of all dirt, debris, and loose and foreign materials. Sandblasting and compressed air are typically used for this purpose.

2. Crack Filler. Check to ensure the cracks are being properly filled with a mixture of sand and asphalt. The asphalt content should be approximately 5% to 10%, and the mixture should be heated from 250°F to 325°F (120°C to 162°C) before it is applied.

507.2.2 Large Cracks and Potholes

Cracks that are greater than 3 in. (75 mm) in width and all potholes greater than 1 in. (25 mm) in depth that are not patched as discussed in Section 506 will be treated in as follows:

1. Preparation. Verify that the cracks and potholes are thoroughly cleaned of all dirt, debris, and loose and foreign materials.

2. Tacking. After cleaning, check to ensure that the cracks and potholes are tacked in accordance with the contract specifications (see Section 408).

3. Crack and Pothole Filler. Immediately after the tacking operation, ensure that the cracks and potholes are filled with the specified asphalt material, or as otherwise directed by the Project Engineer/Supervisor (see Section 401).

507.3 RECORDS AND DAILY REPORTS

See Section 501.7 for applicable guidance on maintaining project records and Inspector's Daily Reports.

507.4 MEASUREMENT FOR PAYMENT

The quantity of work completed and accepted will be measured as the actual number of tons (megagrams) of material used for crack and pothole repair. The Contract unit price will be used for full compensation for all labor, materials, and equipment necessary to perform the work.

Section 550

CONCRETE PAVEMENT REHABILITATION

550.1 GENERAL

Over the life of a concrete pavement, routine maintenance will be performed to maintain the pavement in a sound and satisfactory condition. However, heavy vehicles, high traffic volumes, infiltration of water, subgrade and base deterioration, and corrosion of load transfer devices can, over time, cause pavement distress to the extent that the facility must be rehabilitated. Pavement distress typically appears as transverse, diagonal, and longitudinal cracking; joint spalling; D-cracking; corner breaks; and joint faulting. A pavement condition survey, including destructive and non-destructive testing, will be performed to locate and determine the cause and extent of distress. Based on the investigative findings, a project then will be designed to treat the specific causes of distress and rehabilitate the facility. Each project will differ and generally will include several different types of rehabilitative treatments. Sequencing of the work in proper order is important. A common sequence of treatments prescribed in a typical restoration project is as follows:

1. repair broken slabs,
2. undertake void detection,
3. perform undersealing,
4. perform grinding,
5. reseal joints and cracks, and
6. construct longitudinal edgedrains.

550.1.1 Description of Work

The work for concrete pavement rehabilitation will vary from project-to-project. The rehabilitation project may contain several of the methods discussed in Section 550. It is the responsibility of the Project Inspector to ensure that the work is performed consistent with the Special Provisions and the Contract Plans and Specifications, or as otherwise directed by the Project Engineer/Supervisor.

550.1.2 Material Requirements

The materials used in rehabilitation projects are similar to those used in the initial construction of pavement, except the addition of accelerating and water-reducing admixtures are usually necessary. There also may be a need for special fast-setting chemical concretes. Verify that the materials used are approved and conform to the requirements of the Contract.

550.1.3 Recycling Considerations

Concrete pavement recycling is usually specified where the existing pavement is severely deteriorated and cannot be rehabilitated by other methods. It's primary purpose is to provide a source of quality aggregate for the new concrete mix; however, most of the crushed fines are not recycled because of their high absorption and high angularity characteristics, which tends to inhibit concrete workability. The concrete is broken in place into manageable pieces using diesel hammers, guillotine breakers, pneumatic hammers, hydraulic chisels, and other similar equipment. The pieces are then hauled to a crushing plant, where they are crushed and the reinforcing steel is removed. Once crushed and properly sized, the material may be used as standard aggregate in the production of the new mix. A typical recycling project can produce approximately 1.5 times the coarse aggregate required to replace the pavement to the same width and thickness. Therefore, recycling can supply most or all of the coarse aggregate required to increase pavement thickness and widen lanes and shoulders.

550.1.4 Other Considerations

Review Section 501.1 of this **Manual** for other general topics that should be considered during the project.

550.2 REHABILITATION METHODS

The following Sections briefly discuss typical methods that are used to rehabilitate concrete pavements. Details will be provided in the Special Provisions and the Contract Plans and Specifications.

550.2.1 Crack and Pothole Repair

See Section 507 for guidance on repairing cracks and potholes in concrete pavements.

550.2.2 Full-Depth and Partial-Depth Patching

See Section 506 for guidance on full-depth and partial-depth patching of concrete pavements.

550.2.3 Subsealing and Pavement Jacking

See Section 504 for guidance on subsealing and pavement jacking for concrete pavements.

550.2.4 Grinding, Grooving, and Milling

The following sections discuss topics that should be considered with respect to pavement grinding, grooving, and milling.

550.2.4.1 Diamond Grinding

Diamond grinding is typically specified to restore the riding quality and texture of the pavement surface. It eliminates defects such as joint faulting, ruts, warping, and disrupted transverse drainage caused by high-volume traffic and heavy vehicles. With the exception of joint sealing, all other rehabilitative methods specified will be performed before the grinding operation. The Contract Plans will designate the areas to be ground. Consider the following:

1. Water. Water that is used to cool the cutting blades also controls dust. Verify that the water is removed from the surface (e.g., vacuumed) and the slurry is disposed of properly.

2. Noise. The noise level of the operation should be held to a tolerable level. The Special Provisions may required a maximum decibel threshold.

3. Blade Spacing. The spacing between grinding blades should be adjusted to provide the proper longitudinal corduroy effect, which will be affected by the aggregate hardness.

4. Direction of Operation. The grinding machine generally will operate in the opposite direction of traffic. Support equipment will be oriented in the direction of traffic to reduce confusion to motorists.

5. Cross Drainage. Grinding should progress from the low side of the cross slope to the high side to avoid ponding of water at the shoulder or longitudinal joint. If grinding is only performed on one lane of a multilane facility, the grinding will be daylighted to ensure unimpeded cross drainage.

6. Cones/Striping. Traffic cones will be removed behind the operation, and the pavement striping that is removed will be immediately replaced. Before marking, ensure that the surface is clean and dry.

7. Acceptance. Acceptance is usually based on pavement smoothness criteria. Measure and accept or reject the work based on the provisions of the Contract.

550.2.4.2 Diamond Grooving

Diamond grooving is similar to grinding; however, the spacing of the cutting blades is significantly wider. This treatment is generally used at locations of high occurrences of wet-weather crashes. The resulting treatment provides escape channels for surface water to drain and thus minimized the potential for hydroplaning.

550.2.4.3 Milling

Pavement milling is generally performed in conjunction with a bonded overlay treatment to correct joint faulting, surface irregularities, and provide a bonding surface for the overlay material. With the exception of joint sealing, all other rehabilitative treatments are generally performed before the milling operation. A milling machine, equipped with carbide tipped teeth mounted on a revolving drum, is used to chip away the material in widths that vary from 2 ft. to 12 ft. (0.6 m to 3.6 m). To ensure a uniform texture with no ridges or low spots, the carbide tips must be continually checked and replaced. During the project, verify compliance of the work and consider the following when completing the attachment to the Inspector's Daily Report:

1. project number, date, and other general information;
2. station, width, distance of treatment, and conversion factors;
3. type of removal (e.g., full-depth, profiling only);
4. water, gas valve, manhole locations marked to avoid damage;
5. traffic control devices and flaggers in place;
6. width and length limits of milling established;
7. width and length measurements at all break points recorded;
8. cross-section checked for compliance;
9. haul trucks not interfering with traffic flow;
10. vertical cut faces greater than 1 in. (25 mm) sloped prior to reopening to traffic;
11. pavement cleaned and swept prior to reopening to traffic;
12. sidewalk areas cleaned and swept; and
13. milled material stockpiled off project, unless otherwise specified or directed.

550.2.5 Cracking and Seating

Cracking and seating is specified to reduce or retard reflective cracking in a subsequent overlay by reducing the slab action of the underlying concrete. During the operation, the concrete pavement will be broken into pieces approximately 2 ft. (0.6 m), rolled to seat the pieces firmly against the subgrade, and then overlaid with specified material. The required crack pattern will be designated in the Contract Plans or specified by the Project Engineer/ Supervisor.

550.2.5.1 Cracking Operation

Many types of equipment are available to perform the cracking operation, including pile drivers with modified shoes, truck-mounted guillotine hammers, and whiphammers. The impact force will be varied as required to ensure cracking through the full depth of the slab. Free-falling weights, in general, will not be permitted. Consider the following:

1. Noise. Specialized equipment may be required if the Contract specifies maximum decibel levels. This is especially important in urban areas.

2. Test Sections. Where test sections are specified, verify the equipment for conformance, and ensure the equipment performs the operation as required.

3. Existing Overlay. It is difficult to verify the crack pattern without removing an existing hot-mix asphalt overlay; thus, asphalt overlays are usually removed and reclaimed by milling or other similar means. Prior to the operation, verify that any existing asphalt overlay is removed and disposed as specified.

4. Depth and Control. Cracks should extend the full depth of the slab, which can be verified with water or coring, as needed. Extensive surface spalling along cracks and excessive shattering of the pavement or base should be avoided.

5. Joints and Edges. Particular attention should be given to areas near joints and edges to avoid spalling or undesirable crack formation.

6. Reinforcing Steel. Verify that the bond between existing reinforcing steel and the concrete is being broken. This objective is sometimes difficult to achieve and requires close monitoring.

7. Utilities, Culverts, Curbs and Gutters. Extreme care should be exercised during the cracking operation to protect and prevent damage to underground utilities, drainage facilities, bridge approach slabs, and decks. Do not permit cracking within 5 ft. (1.5 m) of structures and subsurface utilities. Verify coordination with utility companies before the operation begins. The Contractor is required to repair any resulting damage.

8. Traffic. Where needed, a screen should be considered to protect vehicles in the adjacent lane from flying chips.

550.2.5.2 Seating Operation

After the cracking operation, the concrete pieces will be firmly seated against the base or subgrade. The objective of this operation is to place each piece in firm contact with the base at all points, thereby increasing load-carrying capacity. If the pieces are not properly seated, they may rock and cause reflective cracking in the overlay. Two passes with a heavy pneumatic-tired roller is generally used for this purpose, although other equipment and methods may be specified. Steel-drum and vibratory rollers generally are not used as they tend to bridge over the cracked pieces.

550.2.5.3 Pre-Overlay Considerations

After the cracking and seating operation and before the overly is placed, verify that the surface is swept and that the joints are blown out with compressed air to remove any loose or foreign materials. Soft spots or rocking pieces observed during rolling should be removed and patched as specified. Verify the application of a tack coat where required.

550.2.5.4 Overlay Operation

If the cracked section is left open to traffic, it increases the chance of moisture infiltrating the underlying courses. The cracked section will be swept and overlaid, as specified, within 72 hours of the cracking operation.

550.2.6 Rubblizing

A complete evaluation of the existing pavement and an in-depth subgrade soils analysis is usually performed prior to selecting rubblizing as a rehabilitation method. Consider the following:

1. Purpose. Rubblizing is used to break the concrete pavement into small pieces, approximately 9 in. (225 mm) or less in size,

to provide a free-draining aggregate base course for a subsequent overlay.

2. Existing Overlay. Any existing overlay will be removed and disposed of in accordance with the requirements of the Contract (e.g., recycling).

3. Sawing. A full-depth saw cut will be made to sever any abutting concrete that is to remain in place. Verify that salvable slabs are not damaged.

4. Reinforcing Steel. Any reinforcing steel that is exposed during the rubblizing process will be cut off below the rubblized surface and disposed of properly.

5. Soft Subgrade/Voids. Any soft subgrade material identified while rubblizing will be replaced with acceptable material and compacted to specified density. Voids also will be filled as required.

6. Drainage. Verify that drainage facilities are installed where required to provide positive drainage for the rubblized layer (e.g., longitudinal underdrains).

7. Compaction. The rubblized concrete will be compacted with both vibratory and pneumatic rollers. Check to ensure that the equipment used firmly seats the concrete pieces before the overlay is constructed.

8. Maintenance of Traffic. Rubblizing can be accomplished while maintaining traffic in the adjacent lane; however, traffic must not be allowed to operate on the rubblized layer until the overlay is constructed.

550.2.7 Shoulder Rehabilitation

Where existing shoulders are deteriorated, tied shoulders typically are specified as a rehabilitative treatment. However, if the concrete in the outer lane is severely deteriorated by reactive aggregate or "D" cracking, shoulder rehabilitation will not be effective because the tie bars will not properly bond and transfer loads. Consider the following:

1. Tie-Bars/Hook-Bolts. Holes will be drilled in the outer edge of the adjacent pavement slab, and tie-bars or hook-bolts will be grouted in place to provide load transfer support between the mainline and shoulder slabs.

2. Thickness/Cross Slope. Typically, shoulders will be constructed to the same thickness as the outer lane edge of the adjacent slab. To promote drainage, the shoulder thickness is usually tapered at the outer edge.

3. Joints. Transverse shoulder joints should match those in the existing pavement. Spacing of these joints generally should not exceed 20 ft. (6 m). If the mainline joint spacing is greater, verify that intermediate joints are placed in the shoulder. Transverse shoulder joints do not require load transfer devices (e.g., dowel bars).

550.2.8 Bridge Deck Removal

Bridge deck removal will be specified on rehabilitation projects for those bridge decks that have deteriorated to the point where routine maintenance will no longer be cost effective. The purpose of the work is to completely prepare the bridge deck for rehabilitation. During the project, verify compliance of the work and consider the following when completing the attachment to the Inspector's Daily Report:

1. project number, date, and other general information;

2. completion and acceptance of all preparatory work;

3. deck surface sounded and marked as required;

4. reinforcing steel on centerline and marked for proper lapping;

5. proper types of jackhammers (e.g., 30#, 15E);

6. chipping to the bottom of the top reinforcing steel or to a depth of ¾ in. (20 mm) under the reinforcing steel, where required;

7. secondary sounding of deck and areas that have been previously chipped;

8. replacement of damaged reinforcing steel and proper lapping obtained;

9. forms set properly for full-depth areas;

10. sandblasting of deck;

11. exposed mats of reinforcing steel properly tied; and

12. maintaining force account records, where required and areas measured for pay.

Where sandblasting is used, verify that the operation does not damage the epoxy coating of reinforcing steel and require repairs based on the provisions of the Contract.

550.2.9 Bonded Concrete Overlays

Where the existing concrete pavement is in relatively good condition or has been otherwise corrected, a fully-bonded PCC overlay may be specified. Consider the following guidelines:

1. Surface Preparation. To affect a positive bond between the existing pavement and the new overlay material, the surface must be properly clean and prepared. A thin lay of the existing surface will be removed by shotblasting, sandblasting, or cold milling to remove surface contaminants, paint, and all unsound concrete. The residue left on the surface then will be removed by a combination of high-pressure water and air.

2. Grout Application. After the surface is properly prepared, a cement grout will be applied to the completely dry surface just ahead of the overlay paver. Typically, the grout is applied with a combination of a squeegee, broom, and high-pressure sprayer. The grout must not be allowed to set prior to placing the overlay.

3. Temperature. Bonded overlays should not be placed during periods of rapid temperature change (e.g., early spring, late fall). If placed during these periods, use extreme care during curing; otherwise, the overlay may delaminate.

4. Joints. Joints in the overlay should be sawed directly above the joints in the existing slab. To avoid secondary joint cracking, transverse joints should be cut completely through the overlay where the overlay is less than 4 in. thick. Longitudinal joints generally should be cut to one-half the nominal overlay thickness.

550.2.10 Unbonded Concrete Overlays

An unbonded concrete overlay provides an unbonded interface between the existing pavement and the new overlay, which isolates the old and new slabs. This method is very effective for considerably distressed concrete pavements because it effectively retards or arrests reflective distresses. Consider the following:

1. Unbonded Interface Layer. Asphalt concrete is typically used as the unbonded interface layer. The thickness of the layer must be sufficient to affect complete independent action of the old and new concrete slabs. The thickness of the layer will depend on the severity of the pavement distress but generally does not exceed 1 in.

2. Temperature. The concrete overlay must not be placed on an excessively hot or soft asphalt concrete layer. This can become a

significant problem during the summer months because of the ability of the black asphalt material to absorb the sun's radiation. An effective remedy is to use a whitewash of either lime slurry or curing compound to reflect the heat. A thin fogging of water can also be used for this purpose.

3. Joints. Good load transfer can be obtained by mismatching joints between the old and new concrete slabs by at least 3 ft; however, it may be desirable to match expansion joints due to excessive movement of the slabs.

550.2.11 Joints, Cracks, and Sealing

Pressure-relief joints are usually specified at locations where the slab exhibits signs of unusual pressures. The construction of these joints is very similar to that for transverse joints in new pavement construction as discussed in Sections 501.5.12 and 501.5.13 of this **Manual**. Any differences or special treatments will be designated in the Special Provisions and the Contact Plans and Specifications. See Section 503 for guidance on sealing joints and cracks in concrete pavements.

550.2.12 Underdrains/Longitudinal Edge Drains

Subdrainage is a very important pavement rehabilitation treatment. Water is a fundamental cause of most problems associated with concrete pavement distress. A field survey will usually be conducted to determine the location, type, and extent of treatment. Underdrains and longitudinal edge drains are typical treatments. The construction of these systems should be performed with maintenance goals in mind, including performance inspections.

550.2.12.1 Underdrains

Underdrains are typically specified to alleviate the pumping of the subbase and subgrade materials through the pavement. Pipe and mat underdrain systems are very effective where existing subgrade drainage problems exist. Underdrains are usually installed prior to patching. See Section 606 for additional information on underdrains.

550.2.12.2 Longitudinal Edge Drains

The installation of longitudinal edge drains is specified where drainage problems exist on concrete pavements that have a horizontally drainable layer. These systems remove the moisture trapped in the slab/base interface. A properly constructed longitudinal edge drain system can improve the performance of the underlying base and subgrade materials; however, they cannot restore a structurally inadequate pavement. It is common practice to schedule the placement of the longitudinal edge drains after undersealing and grinding operations because of the potential for these operations to contaminate the filter fabric and aggregate backfill materials. Consider the following:

1. Trenching. A trench will be constructed by approved mechanical means along the edge of the pavement. Where a patched section that extends into the shoulder beyond the original slab is encountered, the trench is usually cut around the extension. Once the trench is cut, it is cleaned of excess and foreign material. The adjacent pavement edge is cleaned of excess soil because it will prevent bonding between the slab and the trench cap. Frequently check the trench width, depth, and grade for conformance. Correct line and grade are critical to the hydraulic function of the edge drain.

2. Installation. Approved filter cloth, pipe, and aggregate backfill will be installed in the completed trench by a combination of mechanical and hand methods. Verify that

adjoining sheets of filter cloth are lapped and secured in the trench as specified. Enforce the provisions of the Contract with respect to repair or replacement of any torn filter cloth. Aggregate backfill will then be placed over the filler cloth in the trench and compacted as specified. Verify that the required types of pipe and pipe connections are installed to the specified depth and grade and that the final backfill material does not subsequently alter the hydraulic grade of the pipe.

3. Trench Capping. The concrete produced, poured, finished, and cured for the trench cap will be similar to that used for conventional shoulder and mainline construction. Plastic sheeting can be placed ahead of the concrete hopper to separate the concrete and backfill material in the trench.

4. Lateral Outlet System. Lateral outlet pipe and either cast-in-place or precast headwalls will be installed to remove the water from the longitudinal edge drain system. The slope of the lateral outlet pipe is very important and should be frequently checked for conformance. Conventional concrete placement and finishing techniques are used for cast-in-place headwalls. Where precast headwalls are installed, pay particular attention to the installation to ensure a good fit of the lateral pipe into the headwall, especially on steep embankments. Wire mesh is typically installed over the outlet ends of the lateral pipe to prevent rodents from entering the system. These screens must be periodically cleaned to prevent clogging.

550.3 RECORDS AND DAILY REPORTS

See Section 501.7 for applicable guidance on maintaining project records and Inspector's Daily Reports.

550.4 MEASUREMENT FOR PAYMENT

The Method of Measurement and Basis of Payment will be specified in the Special Provisions and the Contract Plans and Specifications.